FEBRUARY 1955

Journal

VOL. 47 • NO. 2

AMERICAN WATER WORKS ASSOCIATION

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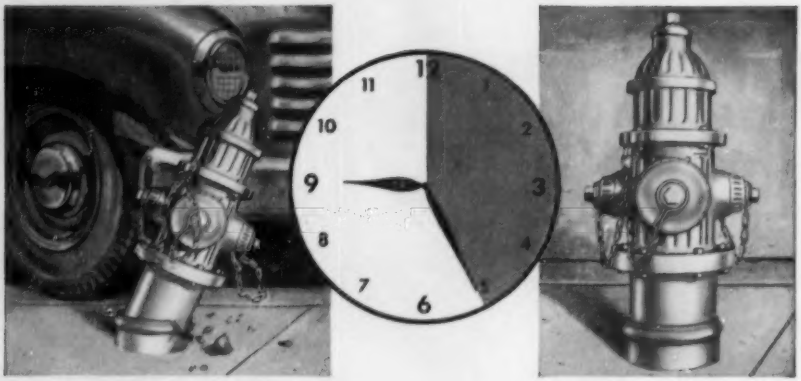

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Journal

AMERICAN WATER WORKS ASSOCIATION

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February 1955

Vol. 47 • No. 2

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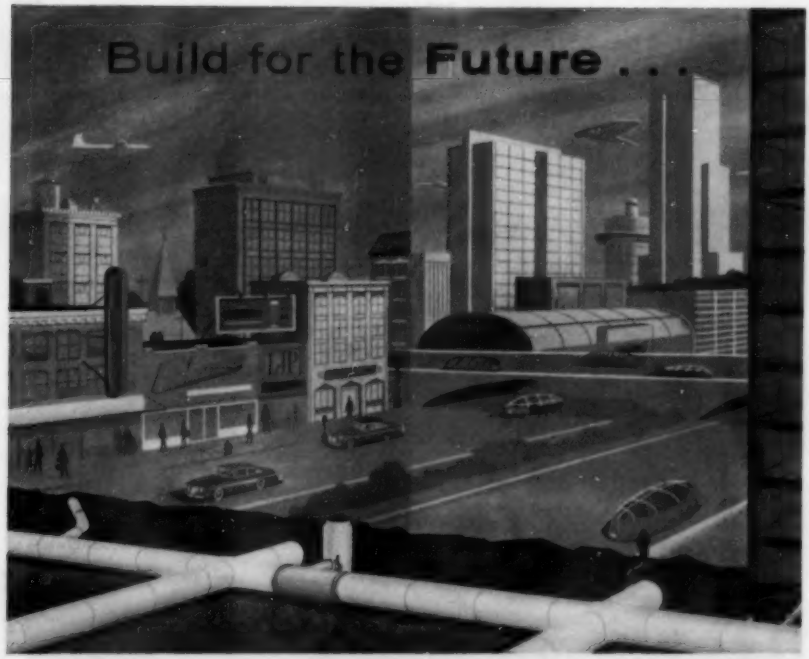

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Coming Meetings

AWWA SECTIONS

Mar. 21–23—Southeastern Section at DeSoto Hotel, Savannah, Ga. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Public Health, 245 State Office Bldg., Atlanta 3, Ga.

Apr. 13–15—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civ. Eng., Univ. of Nebraska, Lincoln.

Apr. 13–15—Kansas Section at Baker Hotel, Hutchison. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 14–16—Arizona Section at San Marcos Hotel, Chandler. Secretary, Quentin M. Mees, Arizona Sewage & Water Works Assn., 721 N. Olsen Ave., Tucson.

Apr. 18–20—Canadian Section at Chateau Frontenac, Quebec. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

Apr. 20–22—New York Section at Hotel Statler, Buffalo. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand St., White Plains.

(*Continued on page 8*)

AWWA ANNUAL CONFERENCE

Chicago, Ill. **June 12-17, 1955**

All reservations are being cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1955 Conference except as they are requested on the standard form, through the AWWA.

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NOW WITH THE RING-TITE COUPLING

Coming Meetings

(Continued from page 6)

Apr. 29–30—Montana Section at Finlen Hotel, Butte. Secretary, A. W. Clarkson, Acting Chief, Water Section, Div. of Environmental Sanitation, State Board of Health, Helena.

May 4–6—Pennsylvania Section at Webster Hall, Pittsburgh. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

May 19–21—Pacific Northwest Section at Hotel Chinook, Yakima, Wash. Secretary, Fred D. Jones, Dist. Supervisor, Rm. 305 City Hall, Spokane, Washington.

Sep. 7–9—New York Section at Saranac Inn, Saranac. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand Street, White Plains.

Sep. 12–14—Kentucky-Tennessee Section at Phoenix Hotel, Lexington, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, 553 S. Limestone St., Lexington.

Sep. 14–16—Michigan Section at Durant Hotel, Flint. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing 4.

Sep. 21–23—Ohio Section at Neil House, Columbus. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 21–23—Wisconsin Section at Hotel Schroeder, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

OTHER ORGANIZATIONS

Mar. 7–11—National Assn. of Corrosion Engrs., Palmer House, Chicago.

Mar. 7–9—Short School (Industrial Sec.) at Texas A & M College, College Station, Tex.

Mar. 16–18—Short Course at Louisiana State Univ., Baton Rouge, La.

Mar. 28–Apr. 1—Western Metals Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

Apr. 5–7—Corrosion Control Short Course, Univ. of Oklahoma Extension Study Center, Norman, Okla.

Apr. 13–15—Conference on Biological Waste Treatment, Manhattan College, New York 71, N.Y.

May 1–5—Municipal Finance Officers Assn., Jung Hotel, New Orleans, La.

May 15–19—European Assn. for Research on Fluoridation and Caries Control, Univ. of Geneva College of Dentistry, Geneva, Switzerland.

Jul. 11–16—Nuclear Engineering Congress, Engineers Joint Council, New York.

Jul. 18–23—International Water Supply Assn. Congress, London.

Sep. 18–22—New England Water Works Assn., Lake Placid Club, Lake Placid, N.Y.

Oct. 10–13—Federation of Sewage & Industrial Wastes Assns., Ambassador Hotel, Atlantic City, N.J.

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Mechanical Joint Tapping Valve with "O" Ring Seal.

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Rensselaer Fire Hydrants are designed on the knuckle joint principle and open with the pressure. They are quick opening with free-flow, long radius curves. Will not freeze or flood and no digging is required for repairs or stand-pipe breakage.

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GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

SALES REPRESENTATIVES IN PRINCIPAL CITIES

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THEY BOUGHT ON FAITH

Photo: Ewing Galloway

Montreal, world's second largest French city, is a great industrial and commercial center. This is a view of the business section, with Victoria Bridge in background.

Montreal's Century Club certificate is unusual because it is bi-lingual.

MODERNIZED cast iron

139 YEARS AGO–THEY BUY ON PROOF TODAY

MONTREAL installed cast iron water mains 139 years ago . . . and still installs them.

The oldest existing cast iron water main on the North American continent is in Montreal, Canada's largest city. It was laid 139 years ago by the Company of Proprietors of the Montreal Water Works.* Several thousand feet of 2½" and 10" cast iron pipe laid in 1816 are rendering satisfactory service as part of Montreal's 1073 miles of mains, of which approximately 96% are cast iron.

*Now, Public Works Dept., Water Works & Sewerage Div.

This cast iron water main laid in Montreal in 1816 is still functioning after 139 years of continuous service.

Montreal's Public Works Department, and utilities in 60 other cities, bought and installed cast iron pipe for underground mains that have been in continuous service for more than a century. They bought on faith founded in good judgment. Today, they continue to buy cast iron pipe because they have *proof*—proof of the long life, dependability and tax-saving economy of this time-defying pipe.

Cast iron pipe has been a rugged, long-lived product from the earliest days. Today's *modernized* cast iron pipe, centrifugally cast, is even stronger, tougher and more uniform in quality. And, where needed and specified, it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout the long life of the pipe.

Cast Iron Pipe Research Association,
Thos. F. Wolfe, Managing Director,
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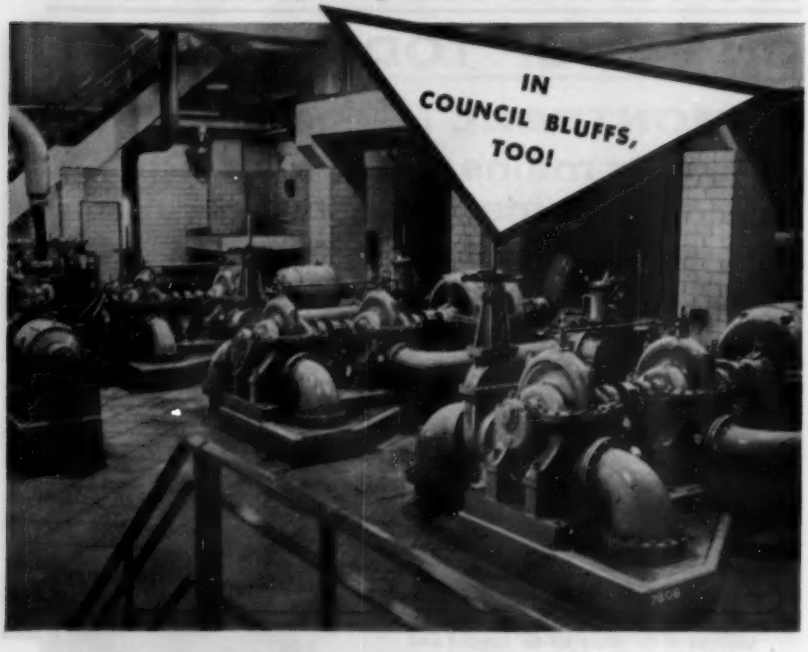

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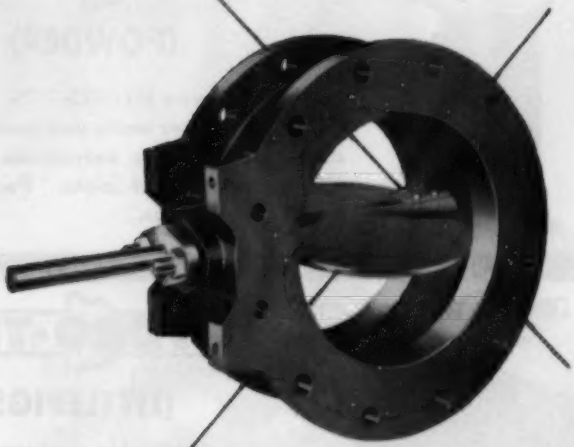

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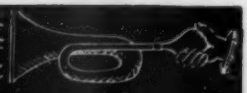

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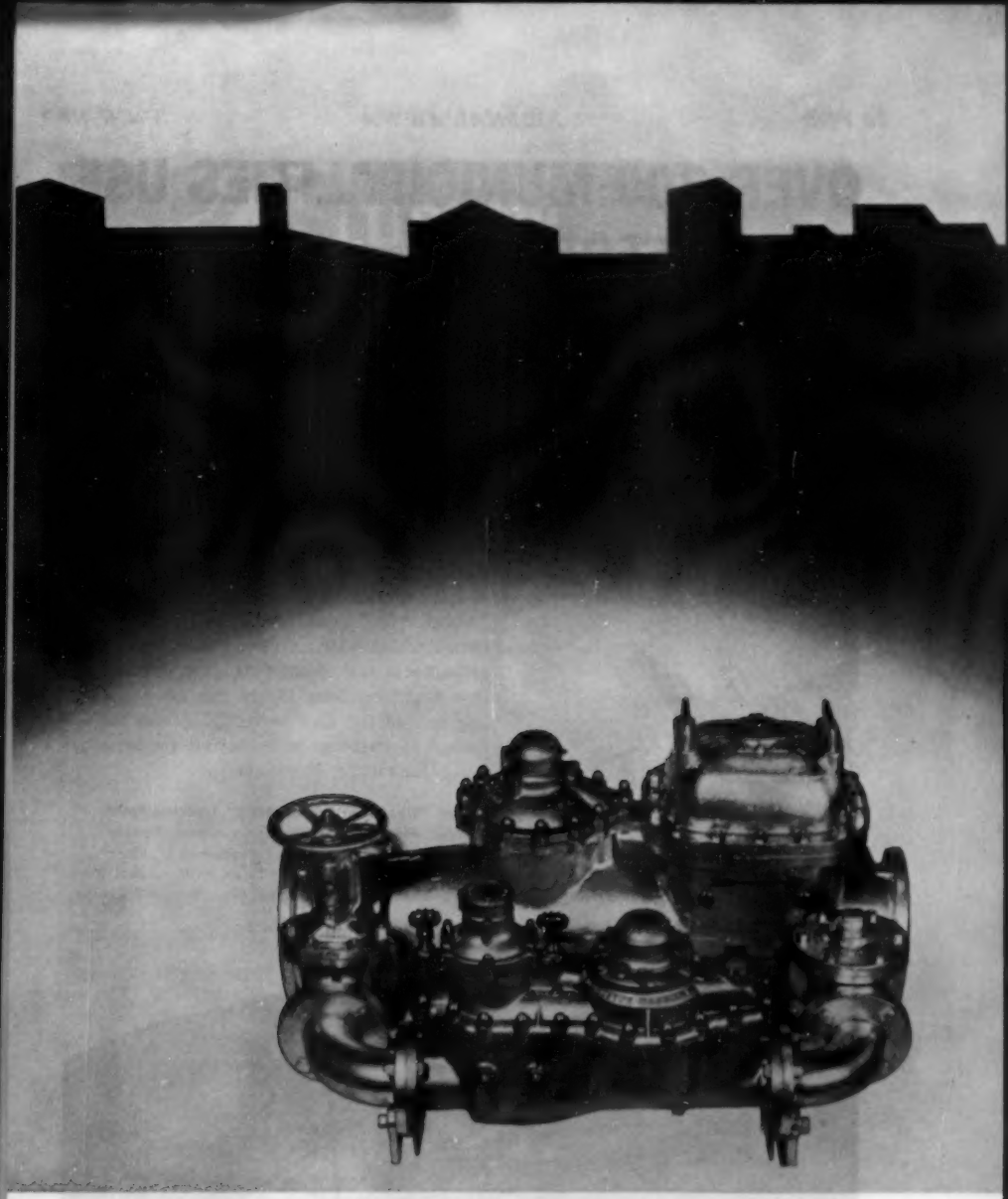

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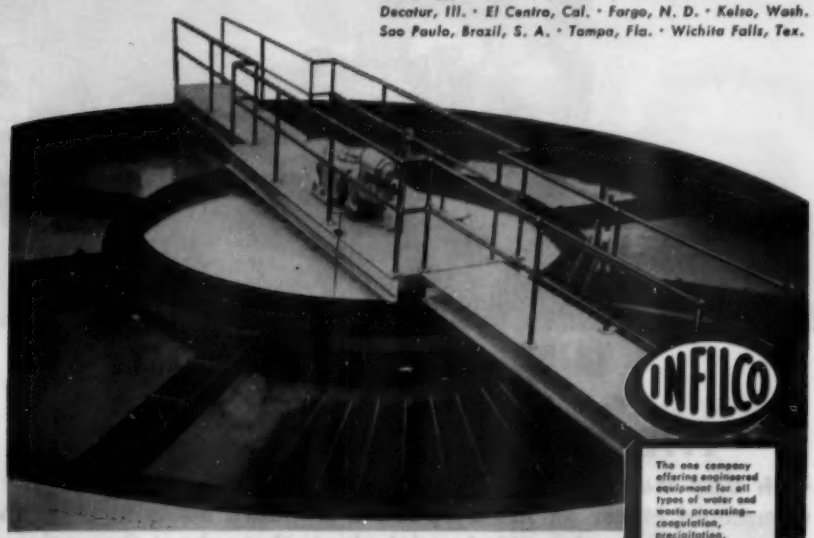
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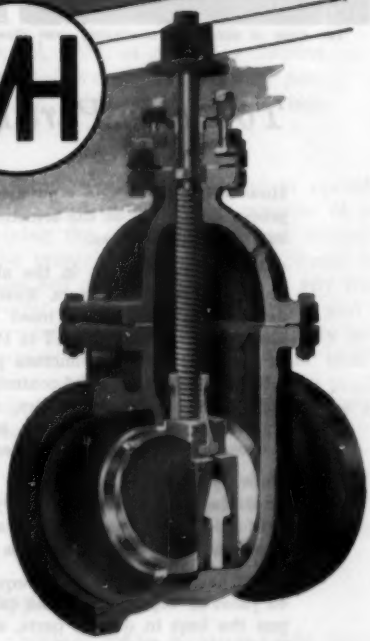

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 47 • FEBRUARY 1955 • NO. 2

Policies on Fringe Area Service in Ohio

Panel Discussion

A panel discussion presented on Sep. 22, 1954, at the Ohio Section Meeting, Dayton, Ohio. (The paper by Pierce Bailey includes portions of an article presented on Sep. 10, 1953, at the Ohio Section Meeting, Cleveland, Ohio.)

George J. Van Dorp

Chief Engr., Div. of Water, Toledo, Ohio.

THE problem of arriving at a proper and equitable suburban main extension policy has long been a subject for discussion. This paper will be confined to those aspects applying to the operation of publicly owned and operated water works in Ohio.

The factors that determine the policy adopted may vary widely between one city or political subdivision and another, from both an operational and a political point of view. In analyzing the situation, it is first necessary to look to the provisions in the Ohio constitution and general code that govern and limit the degree and manner in which a municipality owning a public utility may extend its services to outside areas adjacent to the corporate boundaries. Article 18, Section 6, of the constitution states:

Any municipality owning or operating a public utility for the purpose of supplying the service or product thereof to the municipality or its inhabitants may also sell and deliver to others any transportation service of such utility and the surplus product of any other utility in the amount not exceeding in either case 50 per centum of the total service or product supplied by such utility within the municipality.

Thus, any municipality can sell up to one-third of its total water output for use outside of the corporate boundaries.

Applicable Statutes

Section 3966, Revised Code Section 743–12, of the General Code of Ohio, titled "Extension of Public Utility Service Beyond Corporate Limits," reads:

On the written request of any number of citizens living outside of the limits of a municipal corporation, the corporation

may extend, construct, lay down, and maintain aqueduct and water pipes, and electric light and power lines outside the corporate limits, and for such purpose may make use of such public streets, roads, alleys, and public grounds as may be necessary therefor; provided, however, aqueduct and water pipes shall not extend more than 5 miles beyond the corporate limits.

This section prohibits a municipality from extending mains more than 5 miles outside the city at its own expense.

Section 3967, Revised Code Section 743–13, of the General Code of Ohio, titled "Expense of Service Beyond Corporate Limits," states:

When a person or persons at his or their expense have laid down and extended mains and water pipes or electric light and power lines beyond the limits of a municipal corporation, and the corporation, by resolution of the council, has authorized the proper officer of the water works to superintend, or supervise, the laying and extension of such mains and water pipes or electric light and power lines, the corporation shall furnish water or electricity to the residents and property holders on the line of such mains and water pipes or electric light and power lines subject to the same rules and regulations [under which] it furnishes water or electricity to its own citizens, except that the rates charged therefor shall not exceed those within the corporation by more than one-tenth thereof.

A proposed amendment to this section would raise the permissible surcharge from the present 10 per cent to 25 per cent of the charge made to consumers within the municipality. It should be noted that the limitation on the surcharge for suburban service applies to water furnished through mains laid at the expense of private individuals. It appears that the limitation does not apply when the extension has been made at some expense to the municipality owning the utility. In the latter instance the charge for service may be that which can be mutually agreed upon by the municipal corporation and the customer.

On occasions, the question arises as to what authority is vested in municipal water works management to enforce utility regulations outside the city. This matter is dealt with in Section 3968, Revised Code Section 743–14, which reads:

All ordinances (except those relative to taxation or assessment), resolutions, rules and regulations relative to the construction, maintenance, and operation of water works, mains, hydrants, service pipes, and connections, and the protection thereof, shall operate in like manner in the territory outside the municipality when such extensions have been made, and for the enforcement thereof the jurisdiction of the mayor and police shall extend into and over such territory.

Thus, the authority and power of the mayor and the police of a municipality to enforce the rules and regulations of the division of water extend to all suburban areas where service is rendered. As it is the prerogative of the mayor to delegate this power to duly appointed city employees, it would follow that the water officials, when authorized by the mayor and with the support of the police of the municipality, can enforce water division regulations.

In the event of annexation of a fringe area by a municipality, persons who have installed and paid for water main extensions are entitled to just compensation, according to Section

3969, Revised Code Section 743–15. The usual practice is for the municipality to assume responsibility and ownership of the water lines existing in the annexed area. In view of the General Code provision on the subject, however, it is wise to consider whether certain benefits accruing to the owners of the water lines in the area are not proper and just compensation for the water lines taken over. Such an understanding should be clearly set forth in the articles of annexation.

In connection with the supplying of water by one municipality to another, Section 3973, Revised Code Section 743–19, has this to say:

> A municipality which has water works or electric works may contract with any other municipality for the supply of the latter or its inhabitants with water or electricity upon such terms as are agreed upon by their respective councils. A municipality which has water works may dispose of surplus water, for manufacturing or other purposes, by lease or otherwise, upon such terms as are agreed upon by the director of public service or trustees and approved by the council thereof. Moneys received for such surplus water in either case shall be applied to the payment of the principal and interest of the bonds issued for the construction of such water works, but no lease shall be made for a longer term than 20 years.

This section is interpreted to mean that a municipality having a water works may sell its surplus water to another municipality under mutually agreeable terms, which would not be subject to the surcharge limitations set forth in Section 3967. The quantity sold, however, would be subject to the limitation in Article 18, Section 6, of the state constitution. In addition, Section 3973 limits the duration of the lease contract to a maximum of 20 years.

The foregoing laws are the basis on which policies for extending water service into fringe areas must be established in Ohio. The provisions of the statutes and the constitution are, of course, subject to interpretation by local legal authorities. When their opinions differ, it may be necessary to obtain a declaratory judgment from a local court, under which the water department officials can proceed without fear of legal violation.

Need for Orderly Expansion

The extension of water service into fringe areas frequently presents a sporadic and haphazard pattern, in which water lines may extend long distances to serve some real estate development while entirely bypassing areas located close to the municipal corporation. This situation naturally results in increased cost of service, which usually is substandard because of the great length of the small water mains involved. Furthermore, such uncontrolled and irregular expansion of the water utility becomes one of the major factors contributing to irregular and unsatisfactory expansion of the city itself.

The author has proposed a system of zone rating that might influence the expansion or development to follow a more orderly course. Under this system, the surcharge above the inside-city rate would rise in increments for each successive zone as the distance from the corporation boundary increased. The establishment of such a system would be very much aided by the enactment of the proposed amendment to Section 3967, previously mentioned.

The observations and suggestions in this paper are intended to stimulate thought. It is hoped that they will be helpful in solving some of the problems surrounding the controversial and debatable subject of extending water service into fringe areas.

Pierce Bailey

Gen. Supt., Ohio Water Service Co., Struthers, Ohio.

The problem of extending water service to fringe areas has been experienced by communities, large and small, all over the country. Considerable effort and time have been spent in an endeavor to solve the problem locally. There is, without doubt, an understandable lack of uniformity in procedures and policies throughout the industry. To adopt a uniform policy for service to fringe areas would be difficult because of the varying conditions and regulatory statutes of each state and community.

It must be realized that any attempt to set a uniform policy must take into consideration the essential differences between municipally and privately owned utilities. It is not the intention of this paper to go into these differences in detail; suffice it to say that political-subdivision boundaries, finances, taxes, and accounting procedures for capital charges are the major points which make it hard to establish a common ground. There is considerable evidence and opinion that the responsibilities of municipally and privately owned utilities are similar where they are operating outside the city limits. In the author's opinion, private utilities are more realistic in handling this situation. The methods at hand are clearcut in most instances, and, with the utility commissions exercising checks and private management forced to make money or become insolvent, there is little opportunity for indecision. The slow process of forming "public opinion" and obtaining legislative approval for the necessary measures is a handicap experienced by both types of ownership, but the municipal utility is less fortunate under these conditions, for obvious reasons.

Policies and Procedures

There seems to be no question that water sales to areas outside the city limits should be at a profit to the utility. This implies that main extensions in these areas are to be made entirely at the cost of the applicant or the users of the water. The protection of the "old customer" investment is one of the principal considerations in adopting a realistic policy for supplying water to suburban areas. The cost of enlarging treatment and pumping facilities brought on by continually expanding water service into outlying areas should not repeatedly burden the consumer who has already paid for his part of the system. In conjunction with this is the necessity for getting additional water to the distant areas served, which often calls for the installation of large trunk mains through fully developed areas from the plant to the outskirts of town. This construction is very costly and provides little, if any, benefit to the "old customer," nor does it create substantial new revenue (*1*). The immediate cost of enlarging the distribution system is often the sole expense given consideration, although it is, of course, only a part of the total financial outlay required to provide additional

pumping capacity, distribution storage, reservoir dams, and land.

In the procedures discussed by the AWWA committee on extension policy (*2*) as possible solutions to the problem of extending water service, the question of annexation is mentioned. This is frequently paramount in the minds of those interested and responsible for the normal growth of the parent city and utility. The promiscuous extension of water service to fringe areas will certainly lessen the desire of such an area to become part of a city. If the leverage of water service is applied too strongly, however, the city and utility will run the risk of forcing the area to set up its own facilities, which may forever forestall annexation. The course to be followed is obviously a middle-of-the-road policy. It is possible, because of natural barriers or other considerations, that the best solution is two or more independent water utilities serving the metropolitan area; if it should be decided that this multiple-utility arrangement is not desirable, however, it becomes necessary to consider the right procedure to preserve the beneficial features of a unilaterally owned and operated utility. A contractual relation will provide an opportunity to define all the limitations and conditions under which service will be extended. It has been suggested by the AWWA committee that such a contract could stipulate renegotiation every 5 years. Admittedly this may be a harsh provision, but it is realistic in the face of changing economic trends and increased demands for water. Furthermore, it offers periodic opportunities to encourage annexation and make such changes in the contract as may become advisable from time to time.

It may be possible to express in the contract a desire for a continuing relationship for as much as 20 years and still preserve the 5-year clause providing for renegotiation of the contract elements constituting the charges therein, without affecting other considerations. Certainly, the enforcibility of such a contract would have to be carefully determined. If this 5-year contractual relationship contemplates or provides for eventual ownership of the distribution system by the utility, provision will have to be made to protect the bond indenture, when this method of financing is used. There is in existence in Ohio a contract between a water utility and a county area under which the county issues 20-year bonds to finance the expansion project and which contains the stipulation that ownership of the facilities cannot be transferred unless the utility assumes the obligation of the bonds with the approval of the trustees of the mortgage indenture. This form of contract has been carefully examined and approved by competent legal counsel.

An interesting development in the past few years has been the establishment of sanitary districts and conservancy authorities. Usually they satisfy a specific need and perform their functions as intended. In theory, this method leaves little to be desired in handling a large area comprising many communities. In practice, however, the necessity for observing the sovereign rights of political subdivisions and applying correct and impartial interpretations of the regulatory laws—to mention only two problems—poses restrictions and obstacles to efficient management that are hard to overcome. Metropolitan water utili-

ties are another type of organization, which, in special circumstances, may be the most desirable method for providing suburban water service.

The statement of principles in the 1949 report (*3*) of the AWWA committee on main extensions should be read by utility management with the thought of reviewing existing policies. If a city is now facing the problem for the first time, these principles can be used as a guide or outline to provide a sound foundation for a water main extension policy. The committee, in this report, agreed that, where special assessments are not involved, the utility's investment in main extensions should be based upon the amount of revenue derived from the extension and not upon the width of an average lot, the "free-extension" principle, or similar criteria. The committee pointed out that, with rising costs (even in 1949), the length of free extension justified by revenue return decreases. The committee further suggested that free extensions, if allowed, should be calculated in terms of dollars invested for dollars of revenue in return (which implies a practical adjustment from time to time) instead of on a fixed-length basis, which may not be subject to change because of contract or franchise tenures.

Responsibility for Service

Careful consideration must be given by any utility, whether public or private, to future responsibility for adequate service to fringe areas. It has been held by a Pennsylvania superior court that, if a utility has already expanded service outside the city limits, it is generally obligated to continue such expansion and service, but the utility is entitled to a reasonable return on its expenditure (*4*). The AWWA committee concludes, from a study of court decisions, that a municipally owned utility, although having the power to do so, will not generally be obligated to extend service outside the city boundaries (*1*).

The question of a continuing responsibility to provide adequate service to the community is not unique in the water works industry. Other utilities—electric, gas, telephone, and transportation—have been faced with the same problem, and, in many instances, the considerations are parallel. The obligation of a utility to serve everyone is strengthened by the fact that it is operating as a monopoly and the public, as a rule, cannot choose between several suppliers of the commodity. Full awareness of this fact will add considerable impetus to progress toward a solution of the problem. A water utility desiring to place a limit on its responsibility can define it in a contractual relationship. Limitations can be imposed by setting boundaries beyond which service will not be extended, fixing elevations above which water will not be supplied, or restricting the quantity furnished to a specified daily average. Further stipulations in an agreement can provide that, when service is needed beyond the limitations set forth, renegotiation is in order, to afford an opportunity for setting up appropriate bases to meet the new requirements.

Long-Range Planning

In the design of facilities for extending water service to fringe areas, some factors are giving engineers considerable trouble. These are assumptions about population densities, extent of area to be served, per capita consump-

tion, and ratios of maximum-day to average-day pumpage. The last two considerations are worthy of a word of caution. Existing plant records are an aid in determining these values, but suburban areas, with their heavy sprinkling demands and new homes with modern appliances, will sometimes have a maximum-average ratio much higher than for the entire system. The per capita consumption is, of course, similarly affected. The factors of population density, extent of area to be served, and rate of growth are much more difficult to calculate for design purposes. Fortunate indeed is the designer who has a carefully prepared master plan of the community which places at his finger tips a guide and index to the important assumptions he must make. In general, there is very little evidence of effective long-range community planning, and, where such an effort is being made or is already complete, it is several years too late. Such planning is a joint responsibility of everyone charged with community welfare. Failure to provide it will bring public criticism to the ears of all.

For example, one of Ohio's largest communities has found it necessary to ban all main extensions of any size until new supply projects have been completed. In the meantime the orderly growth of the area will be seriously hampered and, in many sections, will come to a standstill. Small units within this metropolitan community are inquiring into the possibility of setting up and operating their own plants. Every effort should be made to discourage this trend, which will result in many small, independently operated utilities. It is axiomatic that the unit cost of a commodity produced in this manner will be high, and water consumers will express considerable dissatisfaction when they compare their costs with those in adjacent areas where a lower rate is charged. Future annexation will bring many new problems to the parent utility when it attempts to incorporate these independent facilities into its system and apply standard operating procedures and policies.

Payment for Extensions

However sound the plan, it will undoubtedly present many serious problems, particularly with regard to expense. A principal difficulty lies in the apportioning of costs. Here the controversy begins and the battle lines are formed. Political and professional aspirations are at stake, but, more important, the welfare and normal growth of the community are vitally affected by the manner in which this problem is handled. Water works men know that somebody must pay for this expensive service to fringe areas. It is one step further in realistic thinking to decide who pays and how much. It seems equitable for the new customer requiring and benefiting from the service in these fringe areas to pay for its cost—including the expense not only of the facilities fronting his property but also of that portion of the entire system that serves him an adequate supply of water for his needs.

Once it has been established who will pay for the service, the next questions are when and in what proportion. The time of payment should fit the needs of the water utility's financial program and obligations. The proportioning of the costs is subject to two considerations: [1] the cost of the facilities fronting the property, includ-

ing those adjacent to it if participating aid is not available; and [2] the cost of that portion of the system which treats, pumps, and carries the water to the property using it.

Many methods designed to pay for the facilities fronting the property have been adopted. The author's company employs one that is believed to be equitable and practical. This method, when first introduced several years ago, met with considerable objection —very likely, any other would have, too—but has become accepted and even approved of by its former opponents. Briefly, this method places the entire cost of the facilities upon the customer, with provision for the developer to get his money back over a period of 10 years if all the property is developed; or, if the developer elects, he can include the cost in the sale of the lots. The developer is credited with a refund, based upon a 6 per cent return to the company, when a customer applies for service. In any event, the total refund to the developer does not exceed his original deposit with the company. The deposit is determined by the actual cost of the facilities installed, which become the property and responsibility of the company.

Payment for the proportionate cost of treating, pumping, and carrying the water to fringe areas is best handled by a surcharge added to the city water rate. The surcharge method is being used in many communities and varies from 10 per cent to as much as 125 per cent (300 per cent is not unheard of), depending upon the nature of the service required. Multistage pumping and intricate pressure control apparatus may entirely justify high charges. The amount of a surcharge can be readily determined by analyzing the cost of producing and delivering water. The 10 per cent statutory limitation in Ohio has been discussed by another panel member (see page 74). Legal counsel should be consulted to learn whether it applies in a particular case.

The problem of payment for water service to fringe areas is principally a job of selling. The people who need and want water are the utility's best salesmen, but they must be properly informed. To do so, water works officials must be convinced that their method of dealing with the problem is equitable.

References

1. Jackson, L. A. Financing Water Main Extensions. *Jour. AWWA*, **30**:1 (Jan. 1938).
2. Committee Report. Suburban Water Service. *Jour. AWWA*, **45**:697 (Jul. 1953).
3. Committee Report. Water Main Extension Policy. *Jour. AWWA*, **41**:729 (Aug. 1949).
4. Weir, W. V. Suburban Main Extension Policies. *Jour. AWWA*, **44**:399 (May 1952).

A. V. Agnew

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The Lorain, Ohio, policy on water service to fringe areas is rather liberal. Having recently completed a substantial addition to its treatment facilities, the city has water to sell and believes it has a certain responsibility to serve fringe areas, inasmuch as their residents trade in Lorain. There is, of course, a limit to such a policy. No attempt is made to serve large areas where the demand is bound to be light for several years.

Based on a comprehensive study of the fringe areas, trunk and feeder mains have been planned and main sizes established. Any extensions must fit into the proposed system. This requirement is of primary importance, in that it eliminates future duplication and lessens the possibility of dead-end mains.

Several procedures have been used at Lorain to provide water mains in fringe areas:

1. The county sanitary district method is utilized when a relatively large area is to be serviced. A contract is entered into between the city and the county, detailing the services to be rendered by the city and the costs thereof. For example, all maintenance expense is charged to the county at cost plus 15 per cent. The contract contains the usual provision for cancelation by either party upon 90 days' notice. In the event of annexation of the district by Lorain, the mains become the property of the city. The district must submit plans for city approval and must use city specifications for materials and construction.

2. Mains and appurtenances may be installed by real estate developers. Again, plans must be submitted for city approval and its specifications must be used in construction, which is under city supervision and inspection. Before a connection is made to the city system, the developer must present the city with a bill of sale for the new mains. Thereafter the city maintains them just as it does any other part of its system.

3. A third procedure, called the "incremental method," applies to extensions of 500–1,000 ft outside the corporate limits. Usually a number of freeholders join in petitioning the city to install the mains and appurtenances. The city makes the plans and installs the mains with its own forces. The financing of such installations is provided by a payment in escrow, based on the city's estimate of cost prior to construction. In certain hardship cases, property owners may be permitted to sign a contract for payment over a 2-year period in eight installments coinciding with the quarterly billing for water used. Service is discontinued upon delinquency of payment. Ownership of the new mains rests with the city, which furnishes maintenance at no cost to the users.

Another consideration, relating to all three procedures, involves fire hydrants. In Ohio, a municipally owned water works may not expend funds for fire hydrants. There is no problem if the fringe area installation is made by a county sanitary district. Under the other two procedures, hydrants are installed only by the direction of the trustees of the township in question and at township expense. The city has contracts with two townships covering hydrant rentals or ready-to-serve charges, which are on an annual basis and amount to $15 per hydrant.

The outside-city water rate charged is the city rate plus 10 per cent. The amount charged for new service connections and new meter settings is likewise the city rate plus 10 per cent.

Methods of Lime Softening Sludge Disposal

—F. H. Waring—

A paper presented on Sep. 23, 1954, at the Ohio Section Meeting, Dayton, Ohio, by F. H. Waring, Chief San. Engr., State Dept. of Health, Columbus, Ohio.

OF the approximately 450 municipal lime softening plants in the United States, Ohio has 130, serving about 1,750,000 people. The resulting problem of lime sludge disposal is becoming more and more troublesome. In Ohio, 65 per cent (85 plants) discharge the sludge into streams, as compared with about 58 per cent in the country as a whole; 30 per cent (38) of the Ohio plants utilize lagoons or sludge beds, as compared with a similar national percentage; the remaining 5 per cent (7) of Ohio's plants discharge into abandoned quarries or city sewers, except for one plant about which more will be said later.

The use of lagoons or sludge beds is mostly limited to the smaller plants and those not adjacent to streams. Objections to the use of lagoons and sludge beds arise from the fact that, in many places, growing residential areas near the water works consider these devices a public nuisance; in addition, there is the continual labor difficulty and the cost of cleaning.

Objections to Stream Disposal

The use of streams for receiving sludge discharge is subject to increasing objections as people become more and more pollution conscious. The effects of lime sludge upon receiving streams vary considerably, depending on the size of the stream and the amount and frequency of sludge discharge. When basins are emptied of sludge by discharging "slugs" into small streams, the pH of the stream may be raised high enough to harm fish life. There is a definite increase in the visible white turbidity of the receiving waters, and sludge banks are formed on the stream bottom in low-flow periods. Such effects destroy plankton, spoil fish habitats, and create unsightly conditions that at times approach being a nuisance.

According to a 1949 AWWA committee report (*1*), about one-third of the 39 states with lime softening plants were on record as declaring sludge discharge into streams to be a violation of state pollution control laws; four other states qualified their negative answers to the committee survey by stating that each case would be decided upon its merits. Recently the Ohio Water Pollution Control Board has declared lime sludge resulting from water softening to be a pollutant and has requested the Div. of Sanitary Engineering of the State Dept. of Health to recommend permit conditions for all municipalities discharging lime sludge.

It was with this aim in mind that a program of visits to all of the 130 lime softening plants in Ohio was begun in the summer of 1954. As of September only 36 had been visited. At three places, definite complaints about stream conditions had been made; and at one

place, the complaint was directed against an unsightly accumulation of sludge in close proximity to a newly developed high-class residential area. Under the permit system law of Ohio, it will be necessary to view each plant and make specific recommendations on what should be done.

The general practice of discharging lime sludge to streams deserves some comment. Certainly, at flood stages, neither basin slug discharge nor continual drawoff from mechanically cleaned basins can be objected to; on the other hand, such discharge into extreme low water or into practically dry stream beds can easily result in unsightly conditions and complaints. Subsequent flushing of such streams by local freshets can also invite property damage claims from riparian owners downstream. Relatively small sludge discharges on large streams, or where sustained flows obtain, do not seem at present to be important enough to warrant immediate changes in the disposal method. There appears to be no valid excuse for the failure of certain plants to maintain properly sludge beds already provided; this is particularly true of many small plants.

Alternative Disposal Methods

Where conditions seem to require a disposal method other than discharge directly into streams, the use of beds or lagoons, with periodic cleaning out of the sludge, can serve many plants, even of fairly large size, if the site is sufficiently isolated and suitable land is available. This method, however, involves a substantial labor and cost burden. Very large plants—those serving 75,000–100,000 people or more—have the alternative of operating recalcining works. Although there is none in Ohio at present, Miami, Fla., and Marshalltown, Iowa, have operated such works effectively for a number of years. The method is practicable, and can be profitable for large works. Already, Lansing, Mich., serving a population of about 100,000, has nearly completed such a plant. The author, however, is particularly attracted toward an intermediate step—that of caking the lime sludge on a special type of vacuum filter. Subsequent disposal of the lime cake can stop short of recalcining and can be accomplished by sanitary land fill, filling low ground, or spreading upon farmland, all without much difficulty and expense. One such plant is now in operation in Ohio, and its experience will be described in some detail.

The Galion, Ohio, softening plant serves a population of nearly 8,000. Installed in 1945, the 2-mgd plant ordinarily treats water from an impounding reservoir. Well water from some of the original supply works supplements the surface water in the fall of the year, although the city is just completing a new storage reservoir that will more than double the supply of surface water and make unnecessary the use of the harder well water. The surface water averages about 350 ppm in total hardness, and the well water averages 500–550 ppm; the hardness range of the softened water is about 75–80 ppm.

Originally lime sludge was discharged into the city sewers, but the volume was too great for successful handling at the existing activated-sludge sewage treatment plant. As the headwaters of the Olentangy River below Galion dry up during the summer and fall, discharge to the stream is not a satisfactory answer to the disposal problem. During 1954 the city completed and placed in operation a

coil spring vacuum filter * to cake the lime sludge. As far as is known, the Galion plant is the first water utility in the United States to employ such equipment for this purpose. The unit installed at Galion is next to the smallest manufactured by the company. The 4-ft wide drum has a face with a diameter of 8 ft, providing 100 sq ft of filtering surface. The installation was completed in June 1954 and has been operated regularly every day since August. The rate of lime sludge cake production is about 8 lb per square foot per hour, in terms of dry solids, operating with a vacuum of 6–7 in. of mercury. The cake contains about 70 per cent moisture and is readily handled by mobile dumping equipment. The cost of the unit installed, including pumps, piping, and electrical equipment, was about $20,000.

Galion's experience indicates that, for similarly small installations, batch operation of the filter is advisable. Whether batch or continuous operation is adopted, however, it would seem almost necessary to include a sludge concentrator tank to afford at least 1–1½-hr sedimentation of the sludge before drawing it into the filter. If a concentrator were installed at Galion, it would be necessary to run the filter only 6 hr every other day instead of daily. Furthermore, a better cake would be produced from the compacted wet sludge, and settling-basin capacity would not be taken up as at present. Return of the filtrate from the filter to the raw water assists in the softening action and economizes on water. The cake from the filter is readily dried out by spreading on land, and, after 1–2 weeks of average weather, the cake exhibits the characteristics of a firm chalk deposit. Disposal by land fill methods is simple and easy. There is every reason to believe that small works like Galion can interest farmers in utilizing the product instead of purchasing marl for soil application.

Coil spring vacuum filters are being used on digested sewage sludge in several localities. In Ohio, one has been operating successfully for a number of months at Bedford; installations are very nearly ready for operation in the Beaver Creek Sewer Dist. (Montgomery County) and at Lima and Galion; Ashtabula, Dayton, Lorain, Marietta, and Steubenville have units on order.

The application of this equipment to industrial-waste sludges is also in evidence. A large unit in service at the Cincinnati Chemical Co. acid waste neutralization plant has a production rate of 40 lb of calcium sulfate (dry-solids basis) per square foot per hour and uses a drum with an area of 200 sq ft. The sludge cake comes off the filter with a 62 per cent moisture content. The Armco Steel Corp. plant at Middletown, Ohio, has ordered two large units for handling iron scale deposits.

* Equipment manufactured by Komline-Sanderson Eng. Corp., Peapack, N.J., is used.

Acknowledgment

The author is indebted to C. R. Gruber, City Chemist, Galion, Ohio, and to J. H. Bass, Manufacturer's Agent, Robert T. McGivern and Associates, Columbus, Ohio, for much of the information on coil spring vacuum filters presented in this paper.

Reference

1. Committee Report. Disposal of Softening Plant Wastes. *Jour. AWWA*, **41**: 819 (Sep. 1949).

Problems of New Water Utilities

Joint Discussion

A joint discussion presented on Nov. 10, 1954, at the Rocky Mountain Section Meeting, Colorado Springs, Colo.

Northwest Utilities Company—*S. J. Joseph*

A paper presented by S. J. Joseph, Vice-Pres. & Gen. Mgr., Northwest Utilities Co., Denver, Colo.

THE Northwest Utilities Co., a privately owned and financed firm, was incorporated to provide water and sewer facilities for a newly proposed large-scale housing project to be known as the town of Thornton, Colo. As there were few precedents in the state governing such utilities, preliminary rates were established on estimates of costs of construction and operation. Because there was no guarantee on the number of homes that would be sold in the new community, the risk of overdevelopment of the sewer and water facilities from a financial standpoint was present. To minimize the risk, the developer concentrated sales and construction in groups of 400–500 homes. The Colorado Public Utilities Commission, taking cognizance of the fact that the utility's growth would be segmental or in stages, required that quarterly reports be submitted setting forth data on water supply, pumping capacities of wells, monthly drawdowns and recoveries (when possible), water storage, construction of new plant facilities, expansion of sewage disposal facilities, number of homes served, and projected number of customers to be served for the next quarter.

The problem of water supply was solved by evolving a flexible system of wells and designing a plant for treating surface water to be obtained from the Farmer's Highline Canal and Ditch Co., of which the Northwest Utilities Co. controls nineteen shares. The utility has worked very closely with the Ground Water Div. of the US Geological Survey on well development. This agency is to be commended for its valuable assistance and cooperation. Only one well per section is drilled in any of the deep sandstone aquifers, in order to keep interference between wells to a minimum. Pumping tests on all wells are made for drawdown and recovery, and calculations from these data are used to determine the transmissibility and the projected drawdowns of the wells at different pumping rates, based on continuous pumping for various periods. Hence, the life of the wells can be predicted. It may be affected by overdrilling in the immediate area, but the rate of recharge of these aquifers may somewhat offset this condition. Moreover, as the wells are not pumped continuously, their life will be extended considerably beyond their calculated longevity. The deep wells are pumped at rates varying from

70 to 125 gpm. Shallow gravel wells have very high transmissibilities and high rates of recharge with low drawdowns and very fast recoveries. One well has a pumping capacity in excess of 1,000 gpm. At present the utility is completing a five well battery system that will have a rate of 2,500 gpm. By the summer of 1955 an additional supply will be available from a 1,560-gpm plant being built to treat surface water from the Farmer's Highline Canal after passage through a 40-mil gal sedimentation basin. Water use in 1954 is shown in Table 1.

Because all money invested in the sewer and water systems is private capital, every dollar spent, both in engineering and construction, is directed toward obtaining maximum efficiency at minimum cost. As previously stated, facilities are designed in increments, so that it is necessary to make provisions for economical expansion. Careful consideration is given to the planning and budgeting of these items, in order to find out at which point low incremental costs justify the installation of excess capacity. Even though present indications are that the success of the development will meet expectations, conservatism is still a prime factor in the expansion program. It is realized that a large plant built at one time is more economical than the continual expansion of smaller units; a policy of caution has to be followed, however, because the ultimate demand depends on home sales and actual growth of the new community.

A private water company is limited in its methods of financing, as it has no power to tax. It has to rely upon funds from its stockholders, short-term bank or private loans, customer's deposits (a minor item), some contributed capital, and combined first-mortgage and revenue bonds. Regarding the last, it should be noted that a sizable plant must be in existence to provide sufficient actual—not anticipated—revenue to secure the bond investor's money. This situation is further complicated by the fact that most insurance companies, the largest source of long-term capital, require a 5-year earning record. This stipulation eliminates the major prospective purchasers of such bonds for a new water and sewer company, because it is without such a record initially. Furthermore, as the bonds are not tax exempt, interest rates have to be higher than those of municipals to attract buyers.

TABLE 1

Water Use at Thornton, Colo.

Month (1954)	Use per Service* *gpd*
Apr.	253
May	369
Jun.	506
Jul.	419
Aug.	412
Sep.	464†
Oct.	290
Nov.	202
Dec.	145

* Estimated average number of persons per service, 3.6; average size of lots, 7,000 sq. ft.
† Increase in consumption was due to the fact that a number of homeowners started fall lawns.

The privately owned water company is not subsidized by direct or general taxes, and its revenue must be derived solely from the sale of water. Consequently, its monthly bills may appear higher than those of many publicly owned utilities. When taxes and other indirect charges are added to the publicly owned utility's bills, however, it will be found that they are comparable with, and sometimes even exceed, those

of privately owned companies. This is especially true when the communities compared are of similar size and depend upon similar sources of supply. Publicly owned utilities are further subsidized by the fact that they are often tax exempt, whereas privately owned companies are not.

Although publicly owned utilities enjoy tax advantages and can generally establish rates and regulations without reference to a public utilities commission, the privately owned company is favored by a number of other aspects. Perhaps the greatest is the freedom of operation management enjoys. All decisions are made by management, which is accountable to a board of directors rather than to a political body. In regard to financing, bond elections are not required, so that a minimum of time is lost. Although higher rates of interest may be paid, they are more than offset by efficiency of operation. Red tape is reduced. Plant designs are strictly utilitarian and are as automatic as they can be made within economic limits, permitting operation with a minimum of personnel and a maximum of efficiency. A privately owned company cannot carry any dead weight. Hiring and firing do not involve politics.

Supplies and materials for private utilities are purchased by an individual rather than by a board. Some communities and states give local business a 5 per cent preference over outside vendors. Private utilities, which can purchase anywhere at the greatest savings, invariably seek cost advantages. Standardization of equipment, such as water meters, pumps, and the like, can be maintained, reducing inventory investment in maintenance supplies and providing the benefits of interchangeability of parts. At times it may be found that a standardized item may cost a little more than a comparable nonstandard one, but the ultimate cost is less when maintenance and repair are considered, because the personnel are familiar with the standardized item and time is saved. Moreover, the purchasing board of a publicly owned utility has to accept the lowest bid as long as the specifications are met, although the result may be greater operating costs.

With regard to efficiency, the Northwest Utilities Co. has the added advantage of operating in an area of controlled growth. Development is concentrated, so that maximum use can be made of the distribution lines. There are no gaps due to empty lots. This means a lower cost per house served, both in initial investment and in operation.

A privately owned utility company has to be very adroit in its public relations, as it is considered an outsider in comparison to a publicly owned company. Many homeowners fail to understand that they gain no real equity in a publicly owned water utility; should they sell their property, they do not realize their share of the equity. Hence, if a privately owned company can make its allowable profit and still furnish water service to the consumer at a cost equal to or less than the publicly owned utility, benefits are received not only by the user but also by the investor and the country at large, through taxation.

South Adams County District—*Jack H. Maguire*

A paper presented by Jack H. Maguire, Supt. & Engr., South Adams County Water & Sanitation Dist., Derby, Colo.

The South Adams County Water and Sanitation Dist., located northeast of Denver, Colo., serves the three communities of Derby, Dupont, and Adams City. In 1948 the Colorado Health Dept. called upon the several large packing plants at the edge of Denver to stop their sewage wastes from causing pollution of the Platte River. After engineering surveys and reports had been made for the packing plants, a Derby businessmen's group organized a committee to conduct further studies on the sewage problem. As the issue at hand concerned all of the people in the area, the businessmen's group withdrew in favor of a citizens' committee through whose efforts a public election was held to decide whether a sanitation district should be formed and, if so, who should be elected to the board of directors. The vote was favorable, and, on Sep. 20, 1951, orders and decrees establishing a 12-sq mile district were filed with the county clerk. Five men were elected to serve as board members, from whom a president, treasurer, and secretary were chosen.

The board concentrated its efforts on the sewage problem existing in the area. Legal procedure calls for the board to submit a budget to the county commissioners by October of each year, and, upon their approval, the necessary tax is assessed for the following year. All expected costs are considered in making up the yearly budget, from which the sanitation tax is determined. The board was faced with the necessity of keeping the tax as low as possible, in order to get support for the sewage program from the working people in the district. As soon as the district was formed, several industrial plants and individuals asked to have their land excluded from the district because of the expected increase in taxes. Permission was granted upon public notice and the payment of a $50 charge. Other individuals requested inclusion in the district (any landowner having more than 20 acres was automatically excluded), and the policy adopted was to accept such petitions at no charge. This policy actually brought more people into the district to vote on the matter of a bond issue for the installation of a sewage disposal system.

Several public mass meetings were conducted, and an election was held in September 1952, in which the sewage issue was narrowly defeated. The public appeared more interested in a water system than in the sewage problem that originally led to the formation of the district. Another public election was held, offering a water system or a sewage system or both for the people to vote on. The water project was approved, while the sewage issue was again defeated.

The planning of a water system for this spread-out area began with the selection of sites at which deep wells were to be sunk. Six wells were planned, three to a depth of 800 ft and three 1,600 ft. Three sites were purchased approximately a mile apart, and four wells were completed, only one of them being drilled 1,600 ft deep. A 300,000-gal reinforced concrete reservoir, covered and partially underground, was built for each well.

Treatment of the water was planned to meet all requirements of the Colorado Health Dept. A system consisting of approximately 58 miles of water mains was ably designed by the engineers. Data on water production and use are given in Tables 2 and 3.

It is impossible in this brief paper to describe adequately all the detailed problems faced by the board in choosing well sites, pumps, controls, reservoirs, mains, valves, fire hydrants, and so forth—all to be completely installed for $1,500,000, the amount of the bond issue voted by the people to be served. Every item mentioned had to be put out for bids, and the sifting of bids was no small matter.

Before the water system was completed, the problems of water rates, tapping fees, and extension of mains arose. Through the combined efforts of the engineers and the auditor, a schedule of rates was prepared. The rates, which had to be rather high because part of the bond retirement and interest charges was to be met from the sale of water, were based on an estimated initial number of customers. The tapping fee was calculated in a different manner, to keep the cost to the property owner low enough to bring in a large number of water customers. The amount decided on was slightly greater than the cost of materials and labor needed for each installation. A definite number of taps was needed by a certain date to meet financing arrangements, and when the number did not come up to expectations, the tapping fee was raised. The board had the foresight to maintain control of all tapping of the mains, and it is now the practice for taps to be made only by a contractor with a specific contract for meter installations in the district. All water sold is metered, and all meters are installed in pits just outside each customer's property line. The district purchases all the materials used, permitting standardization throughout the system.

Extension of water mains within the district, as well as expansion of the district boundaries, has caused the board additional problems. The superintendent determines the feasibility of main extensions, subject to board approval. As the district is new, there are no surplus funds available to add mains to the system whenever prospective customers request them. Conse-

TABLE 2

Residential and Industrial Water Use

Month (1954)	Residential*		Combined Residential and Industrial		
	Avg Use per Service *gpd*	Avg Cost to Customer *$*	Total Water Consumption *gal*	No. of Services	Avg Cost to Customer *$*
Jan.	422	4.14	3,000,000†	426	5.75
Feb.	443	3.88	3,593,000	473	5.85
Jul.	935	5.31	8,424,000	784	6.11
Aug.	910	4.87	8,860,000	872	6.21
Nov.	570	3.83	7,791,000	1,150	4.57

* Estimated average number of persons per service, 4.5; minimum size of lots, 6,000 sq ft.
† Estimated.

quently, the board decided that, after a certain date, new customers, primarily new subdividers, would be required to pay $2.50 (instead of $1.50 if a sanitation tax had been paid before that date) per lineal foot plus one-half the potential tapping fees on a new main in advance of installation. This policy was adopted to protect existing property owners, who voted the water system in originally and have paid for the mains in their streets through taxation. It was felt that newcomers moving into areas where no lines had been laid should pay cash for the new mains needed, as they had paid no taxes to help finance the system at the beginning. The charge per foot is actually too low, but the district is not a profit-making organization and the program was adopted mainly to promote the growth of the community and the water system. The board purchases all the materials needed for extending the mains and controls their installation. With only one exception, all new extensions have been made through the district office and are standardized with the original system.

The district is responsible to the people residing in it, and it is up to the board of directors to satisfy the needs of some and protect the interests of all. As the district is in no single incorporated town, the board is not subject to political direction or local regulations. Its aim is solely to establish and operate an efficient water system for the taxpayers. The more the area develops and the more efficiently the district operates, the sooner it can reduce taxes. Actually, water rates were reduced after the first 7 months of operation, and no restrictions on use have had to be imposed. The board of directors should be highly commended for the results achieved through its decisions and operating policies.

TABLE 3

Water Production

Month (1954)	Pumped From Wells *gal*	Pumped to Mains* *gal*	No. of Services†	Pumping Cost *¢/1,000 gal*	Avg Cost to Customer† *$*
Feb.	4,758,000	4,715,000	473	5.05	5.85
Mar.	5,434,200	5,310,000	509	4.73	6.02
Apr.	6,821,200	6,406,000	561	4.00	6.42
May	7,903,900	7,236,000	614	3.43	6.95
Jun.	9,856,500	7,842,000	675	3.59‡	6.41§
Jul.	10,802,500	8,821,000	784	3.41	6.11
Aug.	11,431,500	10,748,000	872	2.77	6.21
Sep.	10,974,000	10,151,000	978	2.23	5.54
Oct.	10,034,400	9,305,000	1,057	3.39	4.88
Nov.	8,888,400	8,023,000	1,150	3.30	4.57

* Water used for sprinkling 4 acres of grass at reservoir sites not metered; fire hydrant use not metered.
† Residential and industrial.
‡ Estimated.
§ Water rates reduced as of Jun. 1.

Engineering Assistance Available to Utility Management

John C. Luthin

A paper presented on Apr. 9, 1954, at the California Section Regional Meeting, Monterey, Calif., by John C. Luthin, Cons. Engr., Santa Cruz, Calif.

THIS paper reviews some of the many phases of water utility management where engineering assistance can be used to advantage. The full responsibility for continuous, orderly, and efficient operation lies with management, which, in turn, must depend largely on studies and analyses by engineers and accountants to guide its judgment. Through coordinated efforts, a program can be developed from past experience and predicated on the best possible forecasts of future requirements.

The maintenance of good records is, in itself, the best aid to management in formulating its plans and supporting its program. Regardless of the competence of staff members or consultants, the results of their studies will be only as good as the basic recorded data that they use. Moreover, the continuous compilation of statistical and financial records by clerical help is more economical than the employment of technicians in an attempt to reconstruct and estimate the data for the solution of any specific problem at hand. The time expended by—and, hence, the cost of—specialists or consultants is inversely proportional to the amount of data available to them.

The more obvious functions of engineering are those connected with planning improvements, certain maintenance and repair problems, cost estimating, design of plant facilities, preparation of specifications and contract documents, supervision of construction, and direction of physical operations. In addition, the engineer plays an important part in the correlation of cost records with construction work, proper maintenance of plant investment accounts, appraisals of property, cost analyses, design of rate structures, studies of depreciation rates and reserve requirements, forecasting of revenue and expense data, and analysis of the financial results of operation.

Water utilities as business enterprises are characterized by high capital investment per customer and per dollar of revenue derived. Also, the normal water utility is an ever expanding business. In fact, many California communities are growing so rapidly that the public utilities serving them are primarily in the construction business. The very nature of these operations places the engineer at the top of the list of staff advisers in formulating plans.

Coordination of management, engineering, and accounting is necessary for effective management. Because the operation of the utility is essentially an engineering job, the costs are, in a sense, created by engineering. After the work has been planned, the ac-

counting system for operation and construction costs should logically follow the pattern of the estimates or budget. Through proper cost and general accounting, the engineer is furnished data on the accuracy of past estimates and is provided with basic information for future use. The accountant and engineer must also work closely together on proper allocation of costs, preparation of schedules of overhead distribution to construction, and accounting for depreciation, replacements, and abandonments. The system of record keeping should be such that there is no duplication of records or effort by the engineering and accounting divisions.

Engineering Data Required

The first requisite for orderly operation is the establishment of a plan. The extent of master planning will differ between utilities, but, in general, it may be said that a long-range plan looking 10 years into the future should be developed for source of supply, water treatment, transmission lines, storage, and major distribution facilities. Detailed plans for these and the smaller routine improvements should be prepared several years in advance.

Planning for the present and future can be only as effective as the accuracy and completeness of the basic data available. The following list gives examples of the types of records useful for planning (reference may also be made to an AWWA recommended practice (*1*) on the subject):

1. A continuous record of the number of customers served
2. Water consumption by months, from customer meter records
3. Records of the capacity of wells, streams, and treatment and pumping plants
4. Records of actual output of wells, streams, treatment plants, and pumps
5. Records showing the time of operation of intermittently operated facilities
6. Records of flow requirements for maximum month, day, and hour
7. A map of the distribution system on which leaks and repairs are plotted
8. Pressure charts for strategic points, including all pertinent data relating to such items as draft and operation of pumps at the time the charts were made
9. A map of the distribution system showing proposed long-range enlargement and expansion plans.

From such data the engineer may determine future annual and maximum short-period water demands, size and capacity of current and future plant facilities, weak points in the distribution system, adequacy of local storage and pumping facilities, and other operating and construction design factors. In communities where the present water supply is limited, special records should also be kept to establish the time when supplemental supplies will be needed. Such records would include not only studies of present supplies but also data on stream flow, water quality, ground water levels, and recharge rates of potential supplies.

An actual example will illustrate the need for continuous study of the physical results of operation. A small utility which obtains its water supply from two small streams located within its service area suddenly found that the supplies were inadequate to meet the needs of current expansion. The only definitely adequate supply is a river many miles away, and the cost of developing it is prohibitive. A hurried program of drilling test wells has

proved fruitless. There is also the possibility of using water stored in sand dunes nearby, but several years of experience in pumping from this source would be required to determine the adequacy of the supply, and time is pressing. The only remaining possibility is to utilize another small stream of unknown flow characteristics. Treatment, storage, and pumping facilities must be designed immediately in order for the supply to be available in the near future. The utility's estimate of maximum requirements is a considerably greater figure than can be substantiated by the only present source of information, customer meter readings. As about one-third of the customers are not metered, even these records are inadequate. Consequently, the utility will be compelled to spend a great deal of money to install facilities, some of which may be inappropriately designed or of only temporary value, in order to gain time to study its problems more closely.

TABLE 1

Computation of Rate of Return

Step 1. Computation of Net Revenue	
Operating revenues	.....
Less:	
Operating expenses	.....
Maintenance expenses	.....
Commercial expenses	.....
General expenses	.....
Depreciation expense	.....
Taxes	.....
Uncollectibles	.....
Total deductions	.....
Net revenue	.....
Step 2. Computation of Rate Base	
Fixed capital (original cost)	.....
Construction work in progress	.....
Materials and supplies	.....
Working capital	.....
Subtotal	.....
Less:	
Donations in aid of construction	.....
Customer advances for construction	.....
Reserve for depreciation	.....
Total deductions	.....
Depreciated rate base	.....
Step 3. Rate of Return	
Rate of return = $\frac{\text{net revenue}}{\text{depreciated rate base}}$	

Finance—Privately Owned Utilities

The criterion of proper management of a privately owned utility is its ability to render good service efficiently and to return to the owner a reasonable net earning on his capital investment. As capital additions must be made from the sale of stock or bonds, borrowed money, or the reinvestment of net earnings, it is of the utmost importance that the utility be in a sound financial position at all times in order to attract new capital when needed.

Aside from the usual accounting formulas applied to certain balance sheet figures, the generally accepted test of utility earning capacity is the analysis made when an increase in rates is applied for. The California Public Utilities Commission bases its decision almost entirely on the computed rate of return on a depreciated rate base. A simplified outline of the arithmetical computation is shown in Table 1. If the commission classification of accounts is followed and the accounting procedure is consistent from year to year, the analysis of the results of operation is comparatively simple. Even though utilities may endeavor to follow standardized accounting procedures, no two will adopt the same practices in recording accounting data.

The keeping of accounting records is the responsibility of the accountant, but engineering judgment enters into many of the accounting practices relating to capital and retirement entries. Also, the distribution of overhead and certain clearing accounts, as well as the determination of depreciation expense, is generally an engineering function.

One of the most common errors in accounting is to charge capital costs to operating expenses. Sometimes this is the result of an error of judgment, but often it is done to increase expenses in order to reduce income taxes or to improve the utility's position in anticipation of filing an application for increased rates. The effect of charging capital items to operating expenses is to lose legitimate increases to capital. Such items appear only once when charged as an operating expense, but, when properly charged to capital, they remain in the rate base for future showings before the regulatory body. This type of error often involves further errors in retirement accounting, particularly with regard to replacement of customer services. If the correct procedure is followed, the cost of the new service will be added to capital, and both the capital account and the depreciation reserve will be reduced by the amount of the original cost of the retired service. Failure to follow this practice causes a capital account to become cluttered with nonexistent items and distorts the relationship between capital investment and accrued depreciation.

In addition to the general-ledger capital accounts, the amounts in capital should be broken down to identify the specific facilities included. Such a procedure, which is an aid to proper capital accounting and furnishes valuable records, requires that all construction work, except the installation of services and meters, be charged to work order numbers. Each job must be assigned a work order number, which then becomes a subsidiary account under the balance sheet account for construction work in progress. Upon completion of the job, its total cost can be transferred to the proper capital account as a single item. A property ledger further clarifies the capital structure by housing separate records of all items. A separate sheet, with a full description of the item, as well as the additions and retirements, is used for each land parcel, structure, well, pump, building, and piece of treatment or general equipment. Records of mains, services, hydrants, and meters are generally grouped by sizes and types of items, with a running record for each category. For example, a sheet on 4-in cast-iron mains would show the additions, retirements, and balances of footage and dollar amounts. The total balance in the property ledger must, of course, coincide with the capital balance in the general ledger by accounts and in total. If there is any doubt of the accuracy of the amounts on the books at the time the property ledger is to be started, an appraisal of the properties should be made and, with the approval of the public utilities commission, should be inserted as the beginning capital entry in the general ledger and the property ledger.

Most utilities devote too little care to the matter of depreciation accounting. Setting excessive depreciation rates has some apparent advantages in tax savings and profit concealment but has the serious disadvantage of rapidly increasing the depreciation reserve, with a resultant reduction in the rate base. The effect of overdepreciating

is accentuated in the conversion to the straight-line remaining-life method of computing depreciation currently prescribed by the California Public Utilities Commission. When long remaining lives are applied to overdepreciated capital, the depreciation rates are very materially reduced, and it takes many years to bring the relationship of depreciation expense, depreciation reserve, and rate base into proper balance.

Frequent changes in policy and practice with regard to charging expenses cause the results of operation to fluctuate and make it difficult to ascertain any trends. As the public utilities commission sets rates for the future, it is especially desirable that there be a definite pattern in the financial results of operation, to point toward definite conclusions. One of the most important showings made in current rate proceedings is that of the trend of the rate of return.

Presentations before the California regulatory body must include accurate estimates of the revenue that would have been derived had the proposed rates been in effect during the preceding year, as well as a comparison of revenue under present and proposed rates for the following year. In order to prepare such an analysis, it is necessary to compile data on water use as shown in Table 2. Any number of rate schedules can be applied to these data in determining the most satisfactory way of producing the desired revenue. Rates must be designed not only to yield adequate income but also to distribute the charges for service equitably. Rates should be designed to prevent loss of customers or restraint of consumption because of an undue burden placed on any class.

When a utility is seeking to borrow money, the lending agency requires complete reports on the financial condition. In addition to the usual accounting data, it is advantageous to submit an engineering analysis. Such reports include a description of the water system and its operations, as well as descriptions or charts showing trends of expansion and related data, improvements made in the past, and the program of improvements and additions for the future. An analysis of the financial results of operation, showing the earned rate of return, is of prime importance as an indication to the lending agency that the utility can properly service the proposed loan.

If proper analyses of the foregoing operating criteria are to be made, it

TABLE 2

Water Use Data

1	2	3	4	5
Consumption *cu ft*	No. of Bills Rendered for Consumption in Col. 1	Accumulated Total of Col. 2	Consumption for Bills in Col. 2 (Col. 1 × Col. 2) *cu ft*	Accumulated Total of Col. 4 *cu ft*
0	100	100	0	0
100	300	400	30,000	30,000
200	400	800	80,000	110,000
300	600	1,400	180,000	290,000
etc.				

is essential that satisfactory records be available to support the results. The records must be complete and consistent and must follow prescribed procedures. Statistical data on the number of customers and on consumption must be accurately kept. The method of handling clearing accounts and prorating charges must be consistent. The policy used for charging overhead to capital should be standardized.

Finance—Publicly Owned Utilities

In publicly owned utilities, the need for close coordination of engineering assistance and management in financial matters is as great as in privately owned systems. There is, however, considerable difference in the analysis of operations. The analysis of financial results of operation and the budget for publicly owned utilities will generally follow the pattern outlined in Table 3. The net income remaining after deducting the expenditures from the total income is available for future use. A continued surplus of income over expenditures indicates the desirability of reducing rates and, conversely, a repeated deficit shows the need for an increase in rates.

Municipal utilities often have the problem of attempting to make their budgets and accounting conform to the type of records used for other city departments. The method of budgeting and recording costs is generally not tailored for utility operation, and no standardized procedure is followed. Textbooks, the "Municipal Management Series" published by the International City Managers' Assn., and other manuals on the subject all advocate budgeting and account classifications designed to correlate physical and financial operations for the purpose of analysis and comparison. There is also universal recognition of the desirability of cost accounting. An excellent guide to the proper procedure and practices is the AWWA *Manual of Water Works Accounting* (*2*).

According to the best recommended procedure, a proposed construction program should be shown in the budget in substantially the same form that the engineer uses in preparing the summary of estimated costs. Later, as each job is undertaken, it is assigned a work order number and, by means of cost-accounting methods previously described, the actual costs for each project are properly recorded. With this type of information, man-

TABLE 3

Income and Expenditure

Income	
Revenue from water sales	.....
Revenue from taxes or assessments	.....
Donations in aid of construction (charges for service installations, hydrants, and main extensions)	.....
Total income	.....
Expenditures and Charges	
Operating expenses	.....
Maintenance expenses	.....
Commercial expenses	.....
General expenses	.....
Depreciation expense	.....
Normal capital additions	.....
Payments to public agencies in lieu of taxes	.....
Bond issue interest and redemption charges	.....
Transfers to construction funds	.....
Total expenditures and charges	.....
Net income	.....

agement may control its expenditures and hold to its budget, and the engineer will be provided with data that will aid him in future estimates. Although this general procedure is advocated by authorities on municipal finance, very few cities have adopted it.

Many municipalities, especially the smaller ones, keep all accounting records on a cash basis. The city clerk or accountant develops classifications of accounts designed primarily to make it easy to assign charges, as payments for salaries, wages, materials, and services are made. For proper cost accounting, it is necessary to charge certain items to stock on hand and other clearing accounts, for eventual distribution to the proper account or job at the time of usage. This necessitates having the accounting done on an accrual basis. Because combination accrual and cash accounting cannot be easily reconciled, the tendency is for the city to use cash accounting throughout. Independent cost accounting in the departments is generally unsatisfactory; it is meaningless unless it is an integral part of the general accounting.

One of the most difficult jobs in the management of publicly owned utilities is convincing the governing body of the need for capital items in the budget. The presentation of the budget must be fully supported with statistics and often with data showing the necessity for construction work, the reasons it cannot be deferred, and the proposed means of financing it. Here again the need for long-range programs and detailed planning for immediate improvements manifests itself. A carefully prepared plan, revised each year, must continually be brought to the attention of the governing body and the public, not only to point toward future major projects but also to demonstrate that any curtailment or postponement of capital expenditures may lead to a slowing up of the entire program and to deficiencies in service.

The plan for improvements should be developed in three steps: first, the requirements of the physical facilities must be studied; second, the order of necessity must be determined; and third, the financial requirements must be scheduled to maintain a uniform total annual cost. When major projects have to be financed through bond issues or from reserves, the servicing of the bonds or the reserve requirements become the budget items in place of the direct expenses. If the total annual cost is relatively constant from year to year, the budget will be better received than if it shows wide variations and fluctuations.

In general, the complete accounting and statistical records previously described in the section on privately owned utilities are equally important to the publicly owned utility. The need for accurate capital accounting is not as apparent; nevertheless, there should be proper accounting of capital additions and retirements, and a property ledger should be maintained. Although the total fixed capital of the publicly owned utility does not appear in most operating reports or in the budget, it is still the principal item on the balance sheet. Proper accounting of capital, capital donations, depreciation reserve, and surplus assists materially in showing the community's equity in the plant. A property ledger is also of value in connection with insurance appraisals.

The use of combined accounting and engineering records and assistance is likewise important in connection with bond issues. The salability of the bonds and the rate of interest to be paid are related to the impression created by the management of the utility. The bond houses desiring to bid on an issue must be provided with a prospectus or report designed to substantiate the security behind the issue. The prospectus must include such items as the earning capacity of the utility, proof of the need for the improvements to be financed, a sound program for meeting future financial obligations, evidence of soundness of operating practices, information on the general economy of the community, and whatever other supporting data may be indicated. A history of sound engineering and management, evidence of adequacy of recorded physical and financial operating data, and a good prospectus will enable a utility to obtain bond money at relatively low rates of interest and on the most favorable terms.

Summary

The assistance of engineering to management goes beyond the routine procedure of preparing plans and specifications for currently required facilities. It begins with the promulgation of long-range and overall planning and continues with the subsequent programming of construction details and financing. In order that management may have the means of reviewing the results of operation, the accounting records and methods must be correlated with the engineering estimates.

The first step toward continued good management is to install an adequate system for keeping records. Gathering together existing data will serve as a good beginning. Then, if the records are carried forward, the required material will be available for use by the staff or consultants in making studies and reports for all purposes.

To be most effective, management must take full advantage of the assistance available from specialists. The nature of the water utility business places engineering assistance at the top of the list of these specialists.

References

1. Recommended Practice for Distribution System Records—AWWA C900. Am. Wtr. Wks. Assn., New York (1940); *Jour. AWWA*, 32:181 (Feb. 1940).
2. *Manual of Water Works Accounting.* Municipal Finance Officers Assn. & Am. Wtr. Wks. Assn., New York (1951).

The Consulting Engineer's Contribution to Water Works Design and Evaluation

John A. Carollo

A paper presented on Oct. 19, 1954, at the Southwest Section Meeting, El Paso, Tex., by John A. Carollo, Cons. Engr., Headman, Ferguson & Carollo, Phoenix, Ariz.

THE consulting engineer, through his training and experience, is able to assist the owners (public or private) of water works by estimating the cost of new facilities, estimating the revenue and expenses of new or improved water works, appraising the present worth of existing facilities, making studies of distribution and pumping systems and water supply sources, preparing plans and specifications for new facilities, and supervising their construction. Water works management personnel also assist the owners by operating and maintaining the physical plant, reading meters, billing customers, and selling and furnishing service to old and new customers. Consulting engineers and management work for the same people, the owners of the water works.

It is obvious that comparatively few consulting engineers have had training and experience in the water works field. Many consulting engineers who are experts in railroad, highway, structural, power plant, and airfield design have never seriously thought about water works problems. It is not quite so obvious, however, even to water works men, that, even among the relatively few consulting engineers in this field, there are large differences in training and experience. Some consulting engineers practice on the fringe of the industry, taking only occasional water works jobs. Some have recently entered the field, fortuitously, by being city engineer or manager when a water works improvement became necessary in their community. And even among those consulting engineers who by education, training, and successful experience are qualified to assist water works owners with their problems, variations in specialties occur.

The consulting engineer may be called upon by the utility owner to make an investigation and report on the advisability of acquiring an existing water works or on the installation of a new plant. In such instances, the consulting engineer's contribution is paramount. The success or failure of the venture depends directly on his experience and ability. He estimates the condition and value of the existing water works; he finds additional water supplies; he estimates the growth of the community; he determines the rate structure; and he decides on operating personnel and procedures. The financing of the project depends on his report.

The owner of a water works may be warned by management that relatively large or complicated improvements or additions to existing facilities will be needed in the near future. Management may or may not have ideas about what is needed or how much it will

cost. A competent outside opinion may be desired by the owner, the management, or the financing agency. The consulting engineer can supply this opinion after adequate study.

There are many minor improvements and enlargements on which management needs no assistance from a consultant. The word "minor," however, is a relative term. A project that would be "minor" for a large city might be a "once in a generation" job for a small one. The author believes that consultants should be employed on those projects which are not repeated every year or which cannot be carried out by the minimum permanent engineering staff. This makes good economic sense in two ways. A staff that is built up for a project in a water department is not usually dismissed when the project is completed. Thus, the department is saddled with unnecessary salary expenses, sometimes for years afterward. Also, and more important, engineers in a competent consultant's office are better qualified than those who are working together for the first time.

It may be concluded that, for a small water utility, a consulting engineer should do practically all of the engineering work. At the other extreme, the situation is different. The largest water works in the country employ consulting engineers for special jobs, as New York City did for the Delaware River diversion project, or Chicago for the design of its water treatment plant. The Pacific Gas and Electric Co., with a permanent engineering staff of about 400 for its vast system, employs consultants on any unusual job or even on ordinary jobs in order to avoid large fluctuations in personnel.

In the large group of medium-size water works, such as those of Salt Lake City, El Paso, Albuquerque, Phoenix, Tucson, and San Diego, engineering staffs do an enormous amount of work over the years, but consultants are hired for reports on, and design and construction supervision of, pumping plants, treatment works, and large pipelines. These utilities also employ consulting engineers for rate studies and preparation for rate hearings before commissions.

As a consulting engineer works on many water utility projects in various sections of the country, his experience broadens. He learns by talking to and working for water works superintendents, managers, engineers, and operators. He learns from chemical and equipment salesmen and engineers. He learns something from the mistakes made by others, but more from mistakes made by himself. He either learns quickly, or he is out of work. If he learns, he can be very useful to the busy owner or manager of a water utility.

Feasibility of Biological Warfare Against Public Water Supplies

Bernard B. Berger and Albert H. Stevenson

A paper presented on Oct. 29, 1954, at the Chesapeake Section Meeting, Baltimore, by Bernard B. Berger, Sr. San. Engr., Div. of San. Eng. Services, US Public Health Service, Washington, D.C., and Albert H. Stevenson, Director, Sanitation Div., Health Office, Federal Civil Defense Administration, Battle Creek, Mich.

BIOLOGICAL warfare (BW) against human beings has been defined as the deliberate use of disease-producing microorganisms, their toxins, or the poisons produced by higher animals or plants to cause illness, death, or panic in a target population. Microorganisms that might be used as BW agents may include pathogenic bacteria, fungi, rickettsiae, viruses, and protozoa. An enemy would probably try to disseminate BW materials in air, water, food, or drink. He might conceivably consider other routes that would permit the BW agent to reach the oral or respiratory tracts, or to penetrate the skin. The purpose of this presentation is to discuss whether drinking-water systems may be vulnerable to biological warfare and to evaluate measures that may prevent or control this type of attack.

Water as Vehicle for BW Agents

Enemy interest in the deliberate contamination of drinking-water supplies presumably would be related to the ability to produce disease in a large proportion of individuals in a war-important population. For the purpose of this paper, it is assumed that the enemy would place enough BW agent in the water to produce disease in, say, 50 per cent of the individuals who consumed the water. Owing to differences in personal drinking habits, it is assumed further that this might result in a casualty rate of about 20 per cent. The feasibility of this method of attack would depend on a solution of the logistical problems involved and the ability to overcome the barriers that have been developed to prevent or control naturally occurring waterborne disease. In this connection, the following questions are of overwhelming importance to public health agencies:

1. If pathogens that are normally waterborne are used, would epidemiologists recognize the artificial origin of the attack?

2. If BW agents that are not normally considered to be waterborne are used, would epidemiologists implicate the drinking water as the method of disease transmission?

If the answer to both questions is yes, the defense against this type of operation is facilitated. Defense measures might include boiling of drinking water as a permanent practice or the use of auxiliary water sources of unquestionably safe quality for drinking purposes. In that event, an enemy

would probably consider a BW operation a one-shot affair, to be directed against a number of highly important war populations simultaneously, or as a psychological-warfare operation.

If the answer to either or both of these questions is no, BW defense problems are compounded. Epidemiological opinion on these questions is as follows:

1. If an outbreak is explosive and well defined geographically, and involves 20 per cent or more of the population of the area affected, as indicated, an act of sabotage would be suspected. This opinion is based on the belief that such an outbreak would be unique in current water works experience. If only a small area and relatively few persons were affected, the sabotage might be undetected. Even this is doubtful, as the BW action would probably be aimed at key individuals whose simultaneous illness would certainly be cause for suspicion.

2. If the disease agent were not normally spread by drinking water, it is likely that the outbreak would not be attributed immediately to the water supply, in spite of the knowledge that a common source of infection was involved. If a disease normally spread by arthropods broke out, epidemiologists would probably direct their initial investigation to the presence of the particular arthropod rather than to the water supply. The opinion has been expressed, however, that any disease outbreak attributed to enemy action, regardless of the vehicle of transmission, would lead to the taking of extraordinary precautions in regard to water, food, and milk supplies.

It must be assumed that the enemy would want the attack to create serious disruption in the target population and that the drinking-water system would be considered an effective vehicle for disseminating BW material. By selecting a point of attack, BW material could be directed toward a population of particular importance, and the time it would take to reach the target of interest could be roughly predicted. Every advantage this method provides could be exploited to cause illness among important segments of the population or to cause general panic as part of a psychological-warfare operation.

TABLE 1

Potential Diseases in Biological Warfare

Bacterial diseases	*Rickettsial diseases*
Anthrax	Q fever
Bacillary dysentery	Rocky Mountain spotted fever
Brucellosis	Typhus—endemic, epidemic, scrub
Cholera	
Glanders	
Leptospiroses	
Plague	
Treponematoses	*Toxins*
Tularemia	*Botulinum* toxin
Typhoid	Diphtheria toxin
	Staphylococcus enterotoxin
Fungal diseases	
Blastomycosis	
Coccidioidomycosis	*Viral diseases*
Histoplasmosis	Dengue
Nocardiosis	Encephalitides
	Infectious hepatitis
Protozoan diseases	Influenza
Amebic dysentery	Psittacosis
Malaria	Rift Valley fever
Toxoplasmosis	Smallpox

BW Agents

Many potential BW agents could be used against a civilian population. Some diseases an enemy might produce have been listed by John J. Phair (*1*), Consultant on Biological Warfare, Federal Civil Defense Administration, and are presented in Ta-

ble 1. Many of these agents are stable in ordinary dechlorinated tap water. Others may be made so, although it is generally considered unlikely that protozoan agents would be used. A BW agent would probably be selected for the particular effect it could produce. The factors that would be considered might include:

1. Degree of immobilization desired in target population. It might be consistent with enemy strategy to produce death, protracted debilitating disease, or any other degree of disability.

2. Immune status of population. A BW agent to which a large portion of the target population was highly resistant would probably not be used.

3. Availability of effective prophylaxis and therapy. BW agents for which adequate control and treatment do not exist might be of particular interest.

4. Incubation period desired. It is conceivable that a BW agent might be used that will produce its effect in time to create maximum disruption of a specific production or defense effort of the target population.

5. BW agent characteristics:

a. Stability in the drinking-water system to be attacked

b. Virulence

c. Culturability in the quantity required

d. Resistance to the water treatment processes, including disinfection, which it will encounter

e. Resistance to detection and identification procedures.

It is possible that disease-producing agents not normally found in drinking water may be stable and virulent or toxic in water suspension. It would appear prudent for public health personnel to be particularly alert to outbreaks of nonintestinal illness that show case distribution characteristics normally associated with waterborne disease.

Vulnerability of Water Works

It is quite clear that surface water sources of supply are vulnerable to enemy action. Water utility patrols in watersheds reduce the threat, but obviously cannot eliminate it. It appears safe to assume, however, that the raw-water source may not be an attractive target. Several reasons for this conclusion may be given. The volume of the source may be so great as to require an impracticably large quantity of BW agent to insure desired results. Much of the BW material may be wasted by flow past water works intakes or by biological decay in impoundments and lakes. The opportunities for finding unobserved sites for sabotage are few as compared with the distribution system. Finally, there is the obstacle presented by the treatment plant, where BW material would be reduced in concentration and where abnormal physical, chemical, and biological aspects of the water would be most readily noted.

Information on the ability of standard water treatment processes to remove certain BW agents is not available. Much work has been done, of course, in improving the effectiveness of sedimentation, coagulation and settling, sand filtration, and chlorination in removing or destroying bacteria. Current water treatment practice is geared to the production of water of acceptable bacteriological quality, measured in terms of the coliform group of bacteria. This effectiveness may also apply to fungi if free residual chlorination and a prolonged contact period are

provided, according to recent studies on *Histoplasma capsulatum* by Metzler and his coworkers (*2*). Viruses represent a significant unknown in the water treatment field. Few studies have been made on these organisms, owing to difficulty in growth and titration with the facilities available in laboratories engaged in water quality examinations. The importance of including free residual chlorination as one of the water treatment processes for the removal or destruction of viruses is suggested in studies on infectious hepatitis (*3*) and polio (*4–6*). Peacetime water works practice, as well as protection against biological warfare, requires that additional intensive research be undertaken to evaluate and, if necessary, improve the effectiveness of water treatment methods in destroying viruses. The problem presented by toxins and poisons also requires investigation. Studies on water containing algae-produced toxin indicate that standard water treatment and disinfection processes will not remove this material (*7*). It obviously cannot be said that standard water treatment methods, including chlorination, will under all conditions effectively purify water contaminated with any type of BW agent. Some reduction in such material will, however, be accomplished.

It may be concluded that, although the water source could easily be contaminated, this point of attack might not be attractive, for the reasons described. The application of BW agents to the system after the water has passed through the treatment plant would probably be preferred.

The vulnerability of the distribution system to the introduction of BW agents need not be labored. It would be generally agreed that substantial amounts of an agent could be pumped directly into the distribution system, using readily available portable commercial equipment. It may be assumed that information on distribution system facilities and locations of critical importance has been generally obtainable. In the past little attempt was made to safeguard the plans of the water distribution systems of many large cities. National Board of Fire Underwriters plans, as well as material put out by many water utilities, have been given to any person showing an interest in this information.

Logistics

The feasibility of a BW attack through the distribution system depends on whether BW material that is stable in water and virulent or toxic when ingested could be unobtrusively obtained or produced. There is little question concerning the ability of any person experienced in water works to put this material into the water flowing in the main. The attractiveness of this operation would, however, be affected by the quantity of material needed to produce widespread disease in the population. An estimate of this quantity must be based on the human oral infective dose. Data of this nature are very scanty, as normal peacetime public health and medical practice makes no great demand for such information. The published literature does give some clues to human oral infective dosages for several pathogenic materials, however, permitting at least an estimate of the magnitude of the logistical problem that would be encountered in attempting to contaminate a drinking-water supply.

An idea of the quantities of contaminant needed to produce one human infective dose in every drink contained in 1 mil gal of water is given for the following examples of microorganisms and toxins that are infective by the oral route. For this purpose, a drink of water is assumed to be 100 ml:

1. Less than 1 lb of a preparation of *Salmonella anatum* in 1 mil gal of water would be required to produce salmonellosis in 50 per cent of the exposed population. This statement is based on a determination by McCullough and his associates (*8*) that three of six human volunteers succumbed to an oral dose of 860,000 cells of this organism. These bacteria can readily be prepared in a concentration of 10^{11} organisms per milliliter. It is generally believed that *S. anatum* is less infective than *S. typhosa* and that fewer of the latter pathogen would be required to produce the same incidence of illness.

2. Less than 15 lb of dried, partially purified *Staphylococcus* enterotoxin in 1 mil gal of water would produce poisoning in the greater portion of the exposed population. This figure is based on an analysis by E. P. Casman (*9*) of the studies of Minette (*10*) and of Bergdohl and his coworkers (*11*). It was determined from this analysis that the vomiting dose for man is 0.16 mg dry weight of the partially purified enterotoxin.

3. Less than 10 lb of partially purified *Botulinum* toxin in 1 mil gal of water would produce botulism in more than 90 per cent of the exposed population. This estimate is derived from the work of Lamanna (*12*), Dack (*13*), and their colleagues.

The quantity of BW agent required to produce infection or poisoning is considerably less than that of readily available poisonous chemicals. Using the same frame of reference—one estimated human lethal oral dose in each 100 ml of 1 mil gal of water—it is calculated that 20,000 lb of potassium cyanide and 10,000 lb of sodium fluoroacetate (a highly toxic rodenticide), respectively, would be required. Access to most pathogens probably would not be too difficult. The production of highly concentrated suspensions from bacterial stock cultures may be accomplished in easily improvised equipment. The production of viral and rickettsial agents in eggs or by tissue culture would involve little risk or difficulty on the part of a skilled enemy technician when the basic technique is available. The production of bacterial toxin in quantity may be more difficult but could be done by improvisation. This material could also be surreptitiously imported and stockpiled for a proposed covert attack.

One may not assume from the foregoing discussion that little risk or technical difficulty is involved in the production and application of a sufficient quantity of BW material to contaminate a major portion of a large city's water supply. The relatively small quantities of BW agent required to produce significant illness in concentrated war-important populations of, say, 10,000 persons, however, leads one to conclude that logistical problems would be no deterrent in an operation of this kind.

Water Quality Safeguards

The common chemical, physical, and bacteriological water quality safeguards may not be relied on to detect or destroy a BW agent added to the water flowing through a main. Chlorine

residuals may be overcome or may otherwise be made ineffective; physical appearance, taste, and odor may give no clues to the presence of abnormal materials; and the standard coliform test is clearly unsuited to BW agent detection.

Chlorination

Chlorination, in spite of certain shortcomings, remains the best single protective practice, both as a measure for BW agent destruction and as a device for detecting the presence of material with an abnormal chlorine demand. Complete dependence on current chlorination practices, however, may not be possible for the following reasons:

1. Chlorine residuals are frequently absent or very low at many locations in a water distribution system.

2. In the distribution system, chlorine residuals are measured too infrequently to represent a useful device for detecting the presence of substances with unusually high chlorine demands.

3. Chlorine residuals may be easily destroyed by chlorine-reducing substances like sodium thiosulfate. The application of such material would not be difficult, as it is readily purchased and applied. It has no known deleterious effect on pathogens, and its stoichiometric relationship with chlorine introduces no logistical difficulty.

4. Levels of chlorine residuals, even when high by normal standards, may be inadequate to cope with applied concentrations of BW material. The spores of *Bacillus anthracis* may be inactivated only when exposed to a free chlorine residual of 2 ppm for 30 min (*14*). Pathogenic viruses also require greater chlorine residuals for inactivation than do the common vegetative bacteria of intestinal origin. The viruses of infectious hepatitis (*3*) and poliomyelitis (*4*) and the Coxsackie virus (*15*) will not be destroyed unless free chlorine residuals are present. An appreciable free chlorine residual and contact period may also be required for fungi. In this connection, Metzler (*2*) and his coworkers found that a free chlorine residual of 0.35 ppm and a contact period of 4 hr were necessary to destroy spores of *H. capsulatum* suspended in water. One must assume further that chlorination as customarily practiced is probably ineffective in destroying toxins (*7, 16*).

5. Certain materials may exert their chlorine demand so slowly on the relatively low concentrations of chlorine residual usually encountered in water mains that no significant reduction in BW agent concentration or in chlorine residual is produced in the contact period available. For example, *Bacillus globigii* (a nonpathogenic spore former) requires a contact period 10,000 times greater than *Esch. coli* for inactivation by the same chlorine residual (*17*). Chlorination may be similarly ineffective even for certain vegetative pathogens. The tubercle bacillus, a vegetative cell encased in a waxy capsule, is almost completely resistant to chlorination (*18*).

Despite these apparent shortcomings, proper chlorination will obviously limit the number of BW agents that might be used against water supplies. For this reason, the threat of deliberate contamination of distribution systems can be lessened by strengthening chlorination procedures. Free residual chlorination at the treatment plant and booster chlorination in the distribution system should be practiced to provide free residuals in all important seg-

ments of the system. This is clearly essential to water quality protection. Current schedules for chlorine residual readings at selected representative points in the distribution system should be intensified. The frequency of such observations should be increased at locations that might be particularly important.

Automatic, continuous chlorine residual measuring devices will be useful at key points in the system. Equipment of this type is commercially available. These devices may be connected to alarms and automatic sample collectors that will operate if significantly low residuals occur. The alarm would signify that something untoward had happened; that there had been a change in treatment at the source; that inadvertent pollution was entering a localized section of the distribution system; or that a BW agent had been introduced into the distribution system. Samples collected should be forwarded immediately to an appropriate laboratory for determination of the chlorine demand in the water and for identification of the chlorine-demanding material. Water works and public health officials should not hesitate to warn consumers to boil drinking water if the low chlorine residual recorded represents an improbable occurrence under normal conditions. An analysis of locations where significantly low chlorine residuals have been recorded may throw light on the point of contamination.

At particularly critical points, such as key industrial plants, research laboratories, and civil defense and police headquarters, additional measures might be instituted. Inexpensive devices could be readily developed and installed for continuous operation to signal when a significant drop in chlorine residual occurred. As an alternative, frequent manual chlorine residual observations could be made by available staff members on a 24-hr schedule. Alarms could be given and samples collected in ways already described.

Bacteriological Examination

The ineffectiveness of the coliform test as a detection device for BW agents is indicated by the fact that not one of the pathogens listed by Phair (*1*) will ferment lactose with production of gas. Moreover, the relative infrequency of routine sampling in the distribution system and the lag between sample collection and recording of results make the normal sampling procedure completely unsuited to the protection of drinking water against BW attack. The membrane filter technique for coliform-organism determination will not, of course, change this situation in any fundamental way, as has been pointed out by Kramer (*19*) and others (*20*).

Although the membrane filter holds great promise as an inexpensive and rapid method for the evaluation of bacteriological water quality, in its present state of development it possesses the defects that are inherent in classical bacteriological procedures when considered as a BW agent detection device. The membrane filter may not be applicable to BW agents other than bacteria and, perhaps, fungi, and it does not provide an automatic and immediate warning of the presence of BW material.

It is possible, of course, that no single procedure can be developed that will do these things. Further research will define the usefulness of the membrane filter in the early detection and

identification of BW agents. It may be assumed that such research will contribute to a solution of this problem.

Physical-Quality Tests

The best current information indicates that the deliberate contamination of drinking water with BW material may not affect the physical quality of the water in any significant respect. In an appraisal of the usefulness of this approach to BW agent detection, the following questions were put to the Physical Defense Div. at Camp Detrick, Md.:

1. What is the lowest concentration of a vegetative cell that can be detected in water suspension by direct visual inspection, by taste, by odor, and by a sensitive device for measurement of light scattering?

2. What concentration of vegetative bacteria is equivalent to a turbidity of 10 ppm?

Table 2 shows how sensitive these tests are in respect to bacterial contamination of water. Even granting the subjective nature of the tests, it is clear that they cannot be depended on to detect vegetative bacteria suspended in a concentration of approximately 10^6 organisms per 100 ml. (For *S. anatum*, the oral infective dose effective against 50 per cent of the population is less than 10^6 per 100 ml.) This study showed further that a suspicious turbidity (exceeding 10 ppm) was not imparted to the water until the *Esch. coli* concentration reached approximately 10^9 per 100 ml.

Although the physical changes in the water resulting from BW contamination may appear too slight to warrant consideration as dependable indications of such material, they should not be dismissed as having no value in defense. The rate of water flow in a main varies appreciably within short periods. It is doubtful that deliberate contamination of the water could be achieved without frequent overdosing, particularly as an attempt would probably be made to maintain a BW agent concentration greater than a minimum human infecting dose. Equipment that would permit frequent observations of water from the mains could be simple and cheap. The small investment required for such a device should justify its use.

TABLE 2

Detection of Esch. coli *in Drinking Water*

Test	Bacterial Population per 100 ml	
	Detected	Undetected
Visual (unaided eye)	10^7	10^6
Taste	10^{11}	10^{10}
Odor	10^{11}	10^{10}
Light scattering (microphotometer)	10^7	10^6

Summary and Recommendations

The authors' opinions on the nation's ability to prevent or to recognize and ward off a BW attack through public drinking-water supplies are summarized as follows:

1. Public drinking-water supplies might be an attractive target.

2. A wide variety of potential BW agents is available to the enemy, including those not normally associated with drinking water.

3. It is likely that a BW attack through the water supply system would be either a one-shot effort to produce widespread illness in a number of target areas or a more localized attempt directed against key individuals, with

the expectation that the sabotage might not be recognized. The recognition of a single act of sabotage involving water supplies would automatically lead to the application of extraordinary precautions in all target areas.

4. The distribution system would be a more attractive target than the source of supply.

5. Logistics would present no great difficulty.

6. Substantial free chlorine residuals in important segments of the distribution system represent the best current means of protection. This protection, however, may not be complete under all possible circumstances.

7. Current routine bacteriological water quality examinations are not useful in detecting the presence of BW material.

8. A BW attack may not be accompanied by readily detectable changes in the physical characteristics of the water.

The following recommendations are offered for the improved protection of public drinking-water supplies against enemy use of BW agents:

1. Reinforcement of security measures at the source of supply, at the treatment plant, and at all critical structures in the distribution system.

2. Establishment of effective liaison between water quality laboratories and specialized bacteriological, viral, and toxicological laboratory services through the official civil defense agencies.

3. Evaluation of the effectiveness of currently used water treatment processes in removing or destroying pathogenic viruses, rickettsiae, fungi, and toxins, and initiation of research for the development of new materials, procedures, and equipment to supplement present methods.

4. Strengthening of chlorination measures and continuous observation of chlorine residuals in the distribution system, as suggested in detail in this paper.

5. Installation of simple, uncovered, transparent, flow-through chambers at important locations to permit convenient observation by competent persons of the physical characteristics of the water.

6. Initiation of research directed toward the prevention of sabotage, the development of warning devices, the rapid detection and identification of BW materials, and the development of completely dependable methods of water decontamination. Although much of the research must be conducted in laboratories having specialized facilities, there are opportunities for the ingenious water works engineer, chemist, or biologist to do original work on the problem.

7. Location of dependable, safe, and easily protected auxiliary sources of drinking water for use if sabotage of the public supply is suspected and if decontamination may not be applied with confidence to the water from the mains.

References

1. PHAIR, J. J. The Diagnostic Laboratory in the Civil Defense for Biological Warfare. *Am. J. Pub. Health*, **44**:43 (1954).
2. METZLER, D. F.; RITTER, C.; & CULP, R. L. Effect of Standard Water Purification Processes on the Removal of *Histoplasma capsulatum* From Water. *Am. J. Pub. Health*, **44**:1305 (1954).
3. NEEFE, J. R., ET AL. Inactivation of the Virus of Infectious Hepatitis in Drinking Water. *Am. J. Pub. Health*, **37**: 365 (1947).
4. LENSEN, S. G., ET AL. Inactivation of Partially Purified Poliomyelitis Virus in Water by Chlorination. *Am. J. Pub. Health*, **39**:1120 (1949).

5. CARLSON, H. J.: RIDENOUR, G. M.; & MCKHANN, C. F. Efficacy of Standard Purification Methods in Removing Poliomyelitis Virus From Water. *Am. J. Pub. Health*, **32**:1256 (1942).
6. KEMPF, J. E., ET AL. Effect of Aluminum Hydroxide, Sedimentation, Sand Filtration, and Chlorination on the Virus of Poliomyelitis. *Am. J. Pub. Health*, **32**:1366 (1942).
7. WHEELER, R. E.; LACKEY, J. B.; & SCHOTT, S. A Contribution on the Toxicity of Algae. *Pub. Health Rpts.*, **57**:1695 (1942).
8. MCCULLOUGH, M. B. & EISELL, C. W. Experimental Human Salmonellosis. *J. Immunology*, **66**:595 (1951).
9. CASMAN, E. P., Federal Food and Drug Administration. Personal communication.
10. MINETTE, F. C. Experiments on *Staphylococcus* Food Poisoning. *J. Hyg.*, **38**: 623 (1938).
11. BERGDOHL, M. S., ET AL. Partial Purification of Staphylococcal Enterotoxin. *Arch. Biochem. & Biophys.*, **33**:259 (1951).
12. LAMANNA, C.; EKLUND, H. W.; & MCELROY, O. E. *Botulinum* Toxin (Type A), Including Study of Shaking With Chloroform as Step in Isolation Procedure. *J. Bact.*, **52**:1 (1946).
13. DACK, G. M. *Food Poisoning*. Univ. of Chicago Press, Chicago.
14. MOORE, E. Fundamentals of Chlorination of Sewage and Water. *Wtr. & Sew. Wks.*, **98**: 130 (1951).
15. CLARKE, N. A. & KABLER, P. W. The Inactivation of Purified Coxsackie Virus in Water by Chlorine. *Am. J. Hyg.*, **59**:119 (1954).
16. JORDAN, E. O.; DACK, G. M.; & WOOLPERT, O. Effects of Heat, Storage, and Chlorination on Toxicity of *Staphylococcus* Filtrates. *J. Preventive Med.*, **5**:383 (1931).
17. PHILLIPS, C. R. Relative Resistance of Bacterial Spores and Vegetative Bacteria to Disinfectants. *Bact. Rev.*, **16**: 2:135 (1952).
18. MCCULLOCH, E. C. *Disinfection and Sterilization*. Lea & Febiger (2nd ed., 1945).
19. KRAMER, H. Protecting Water Supplies Against Intentional Contamination. *AWWA Willing Water*, No. 26, Supplement (Feb. 1954).
20. Operation and Repair of Water Facilities in Civil Defense Emergencies—TM 13-2. Federal Civil Defense Admin., Washington, D.C. (1953).

Long Beach Meter Repair Shop and Testing Facilities

Fred S. Porter

A paper presented on Oct. 29, 1954, at the California Section Meeting, Long Beach, Calif., by Fred S. Porter, Div. Engr., Water Dept., Long Beach, Calif.

THE meter repair shop of the Long Beach, Calif., Water Dept. is located in the department's service plant, 4 miles from the main office. The plant also includes the main storeroom, material storage facilities, the machine shop, and the field offices. All water main, service construction, and repair crews are dispatched from this plant.

In the design of the meter repair shop, the comfort and health of the employees were given great consideration. The shop is provided with adequate light, ventilation, tools, heating units, and such other items as soft rubber mats in working areas. Many ideas have been developed to reduce time and effort in the repair of meters and still secure a high degree of accuracy.

The main shop, a room 50 ft square, is in the same building as the 10 × 20-ft acid room. Both rooms are plastered and have 12-ft ceilings. The ceiling of the main shop has a covering of 1-in. acoustic tile, which has materially reduced the noise from the operation of the impact wrenches, the compressed air employed in cleaning and drying meter parts, and the like. This arrangement for the workmen's comfort has had a good effect on their general morale, which is reflected in the quality and quantity of work produced.

Both the main shop and the acid room have large windows, with many fluorescent lights placed over working and storage areas. The bay in which the large-meter test equipment is located is illuminated with floodlights. The main shop is well ventilated and is heated with three 50,000-Btu forced-air gas furnaces.

Shop Layout and Equipment

The repair benches, testing facilities, and parts and meter storage shelves and bins occupy 2,100 of the 2,500 sq ft of floor space in the main shop. The balance is taken up by the 6 × 9-ft locker room, the 9 × 10-ft meter foreman's office, and the 11 × 17-ft register and gear train repair room (Fig. 1).

The main shop is equipped with six repair benches, a ½-in. drill press, a combination grinder and buffer with a built-in dust collector and filter, ample steel storage bins for meter repair parts, steel shelving to store meters up to 2-in. size, and a steel counter for issuing meters. The shop is also equipped with recording water pressure and temperature gages.

Each meter repair bench (Fig. 2) is furnished with hot and cold water and compressed air. All of the meter test benches are also supplied with compressed air to operate the auto-

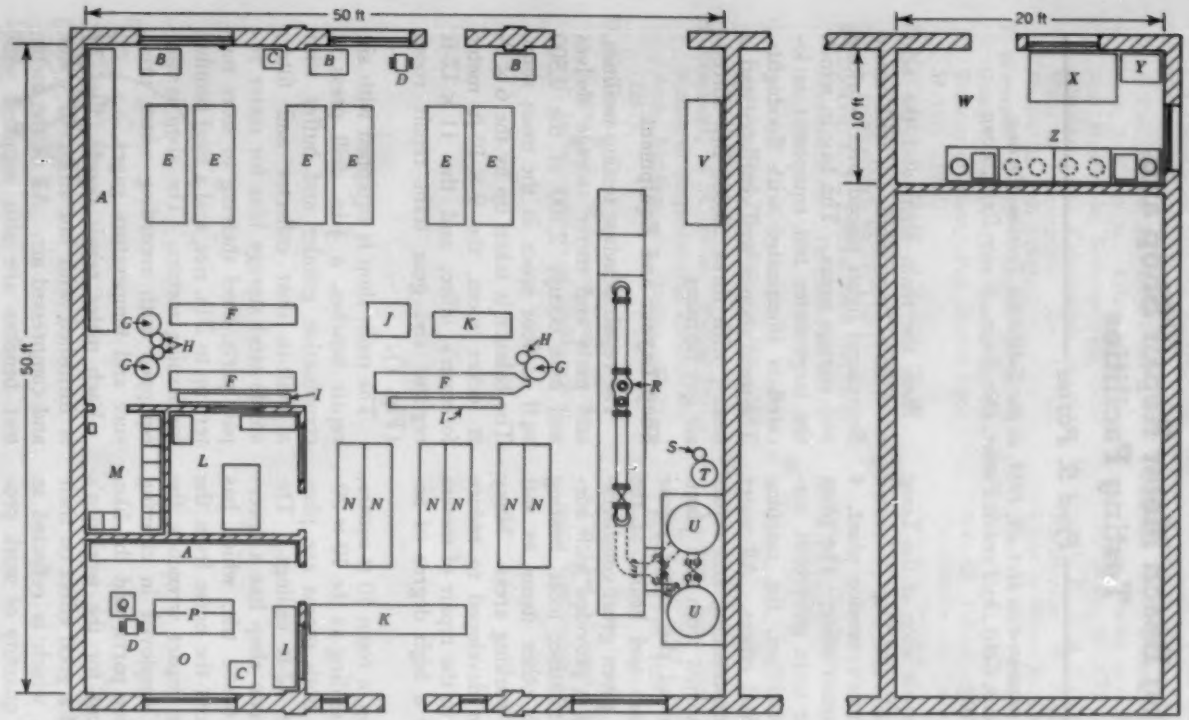

Fig. 1. Meter Shop Layout

A—*meter repair parts storage;* B—*cabinet bench;* C—*drill press;* D—*grinder;* E—*meter repair benches;* F—*meter test bench;* G—*10-cu ft tank;* H—*1-cu ft tank;* I—*cabinet;* J—*table;* K—*counter;* L—*office;* M—*locker room;* N—*meter storage shelves;* O—*register and train gear repair room;* P—*workbench and small-parts storage;* Q—*dust collector;* R—*large-meter tester;* S—*1.5-cu ft tank;* T—*15-cu ft tank;* U—*150-cu ft tank;* V—*storage shelves;* W—*acid room;* X—*workbench;* Y—*shelves;* Z—*hooded acid bath bench.*

matic water shutoff valves, and it is available at numerous other points in the shop where it can be useful.

The repair benches, which are 36 in. wide, 8 ft 9 in. long, and 34 in. high, have a 24 × 30-in. sink at one end and working space at the other. The base is of structural steel, with provision for adjusting the height of the bench to suit the individual repairman. The deck and sink are constructed of 12-gage stainless steel. Each bench is fitted with an adjustable stainless-steel jack to hold $\frac{5}{8}$ × $\frac{3}{4}$-in. and 1-in. meters during repairs. An air impact wrench is suspended from a balance and attached to a standard sliding-door type trolley and track extending the length of the table. An automatic oiler is installed in the air line ahead of the $\frac{3}{8}$-in. rubber hose to each impact wrench. Each bench is fitted with two sections of standard steel shelving, partitioned into small compartments for meter repair parts and tools. For every pair of repair benches, there is one steel cabinet bench, 36 × 24 × 34 in., which is fitted

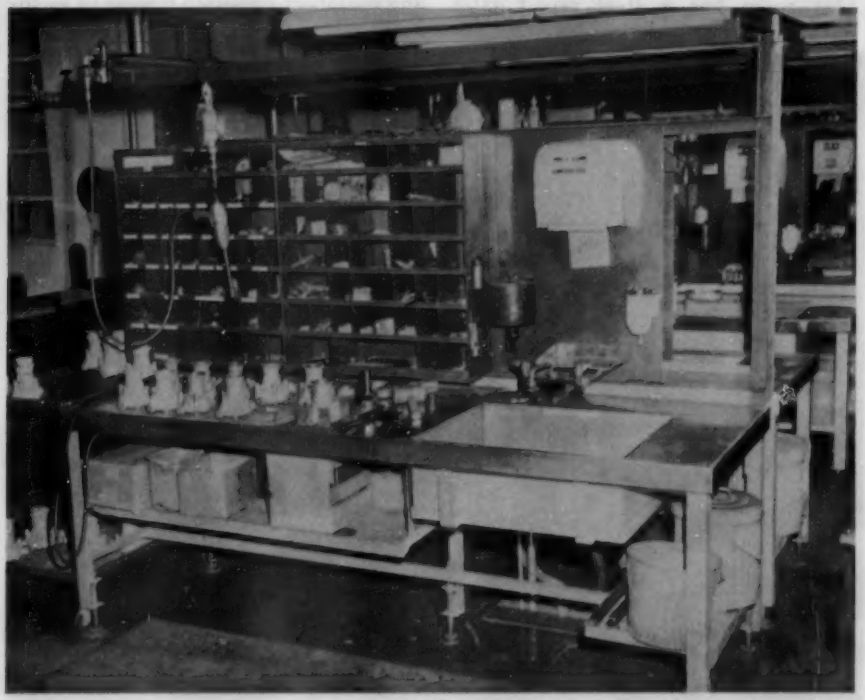

Fig. 2.—Small-Meter Repair Bench

The bench has a stainless-steel top and is furnished with hot and cold water, as well as with compressed-air facilities.

with an anvil vise, used when numbering meters, repairing and installing meter lids, and so forth.

A separate room, 11 × 17 ft, has been provided for the repair of registers and train gears, thus making it possible for the repairman to work away from the noise of the main shop. This room has a steel repair table equipped with steel drawers to hold the various parts required. There is also a ½-in. drill press and an 8-in. grinder and buffer, to which is attached a collector for the dust and dirt from the cleaning and buffing operations.

Acid Room

There is a great difference of opinion regarding the use of acid to clean meter parts. When Long Beach secured its water entirely from wells, little or no corrosion occurred in the meters. The cleaning of the measuring chambers consisted mainly of washing them with a brush and cold water. The water now supplied through the meters, however, attacks the metal in the measuring chambers to such a degree that the department has adopted an acid bath method of cleaning them. An acid room, isolated from the meter

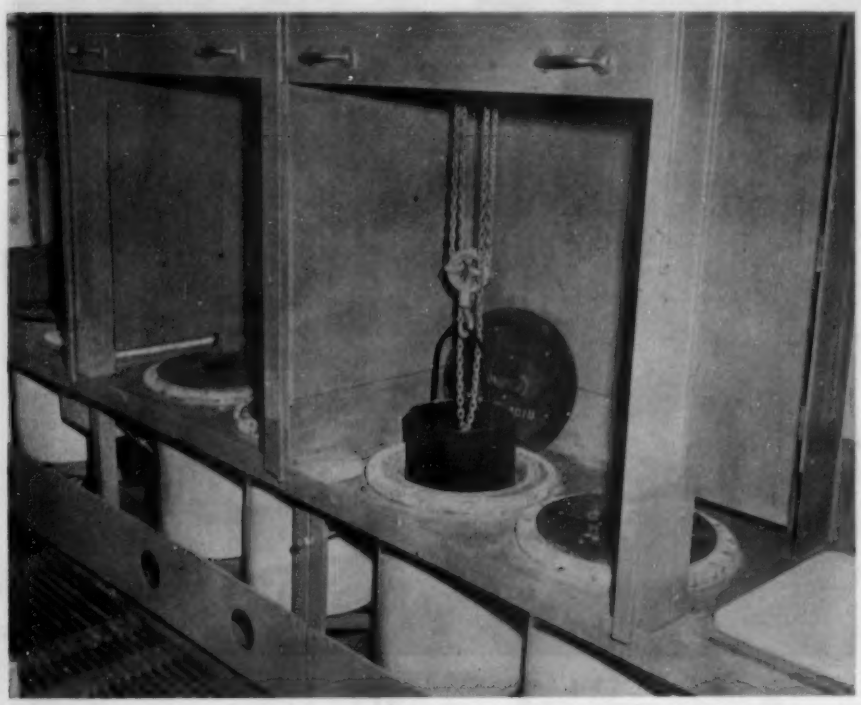

Fig. 3. Hooded Acid Treatment Units

A chain block is used to move the baskets loaded with parts in and out of the acid bath.

shop, has been provided. The room has two acid treatment units (Fig. 3), each consisting of two 20-gal, 18 × 27-in. earthen jars for the acid, an 18 × 20-in. porcelain sink, and a 20-gal jar for neutralizer. The units are mounted on a structural-steel frame. The jars and sinks are connected at the bottom with acidproof rubber pipe and fittings for draining acid, neutralizer, or wash water. The spent acid is drawn off in a rubber basket, transferred to an acidproof container, and spread on the ground at a location that will not cause contamination.

The acid jars are covered with an acidproof hood, made of asbestos-cement board, connected at the top to a suction fan, which carries off the fumes produced by the acid treatment of the meter parts. The room itself is provided with a separate ventilator through the roof from high in the skylight.

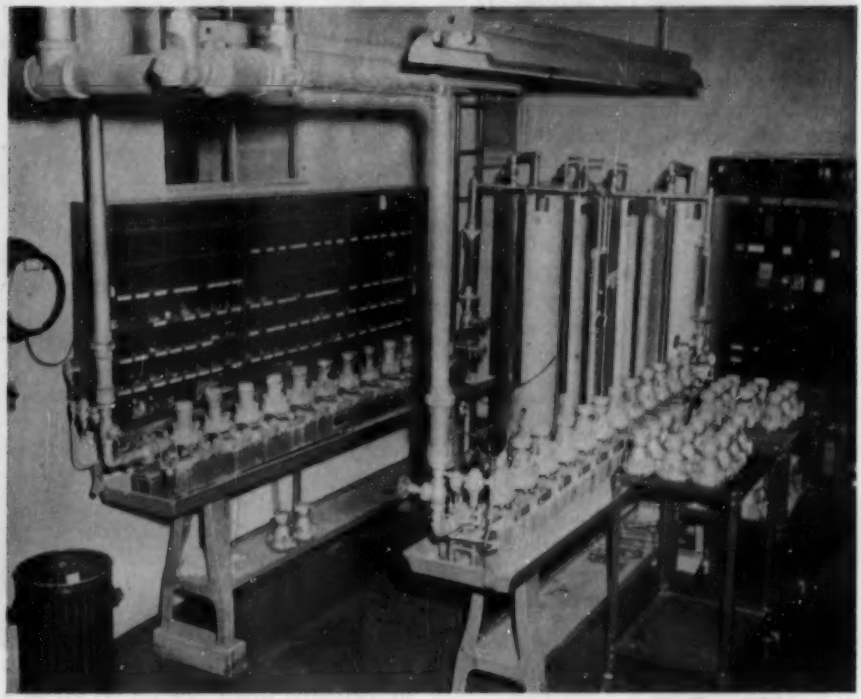

Fig. 4. Hydraulically Operated Test Benches

Each has a capacity of twelve ¾ × ¾-in. meters.

The meter parts to be treated are placed in rubber-covered steel baskets, which are lowered into the acid. A basket may contain as much as 50–75 lb of parts at one time. To handle this heavy load, a small chain block, suspended from a standard light sliding-

door track and trolley, has been provided. The baskets can be moved in and out of the acid, the sink, and the neutralizer jar with no danger to the repairman.

Testing Facilities

The meter-testing equipment includes two benches with hydraulically operated clamping mechanisms (Fig. 4). Each has a capacity of twelve $\frac{5}{8} \times \frac{3}{4}$-in. meters and will accommodate only this size. Each bench is fitted with a rate-of-flow indicator, graduated to register flows from 0.25 to 34 gpm; an electrically actuated, quick-closing, pneumatic shutoff valve; and a 1-cu ft and a 10-cu ft calibrated tank. The tanks are equipped with electrodes to actuate the shutoff valves when the tanks are filled to capacity.

There is also a test bench with a manually operated clamping mechanism, which has a capacity for testing ten $\frac{5}{8} \times \frac{3}{4}$-in., eight 1-in., six $1\frac{1}{2}$-in., or five 2-in. meters. This bench is fitted with a dual-range rate-of-flow indicator, similar to those previously mentioned, which registers flows from 0.25 to 175 gpm. The quick-closing valve is used for flows ranging from 0.25 to 30 gpm. For greater flows, a hand-operated plug type shutoff valve is used.

Large-Meter Tester

The facilities for testing large meters incorporate many of the features of a patented design, but the layout has been modified to provide more than twice the capacity of the original design and to meet special requirements at Long Beach (Fig. 5). Some features were added for ease of operation and for increasing the accuracy of test results.

The outstanding feature of the design is the method of recording the amount of water for each test, at a constant rate of flow throughout the entire test period. (This differs from the ordinary installation, in which only part of the test is made at the desired flow rate, because the control valve must be opened and closed slowly to prevent water hammer.) An electrically operated device starts to record as the water rising in the tank touches an electrode. The recorder is stopped when the water reaches a higher electrode, which is set to measure a selected volume. The amount of water to be used in any one test may be 50, 100, or 200 cu ft. Before the registration test starts, sufficient water is allowed to enter the tank so that turbulence is practically eliminated. There is no surge at the completion of the test, as the water continues to enter the tank at the rate of flow set for the test until the control valve is slowly closed. The $\frac{3}{4}$-in. electrodes are enclosed in stilling wells of $1\frac{1}{2}$-in. copper tubing, which further lessens the effects of turbulence.

Water is supplied to the large-meter tester through two 6-in. pipelines connected to a 20-in. main. The tester is constructed over a pit 3 ft wide, with a depth varying from 18 in. to 21 in. at the end where it empties into a 12-in. cast-iron drain line connected to a 36-in. storm drain. The pit is covered with steel floor grating, which allows any water spilled when breaking down the piping at the conclusion of a test to fall into the pit. Thus, the men have a dry area to work in at all times.

The inlet pipe to the tester is carried below the floor level in the pit. At one end of the pit, the pipe is brought above the floor level to a height of 19 in. and fitted with a

flanged ell, to which telescoping adapters to fit the inlet of 3–10-in. meters may be attached. Nontelescoping adapters are connected from the outlet of the meter to a control valve that regulates the rate of flow for the tests. The overall length of the tester is sufficient to allow a meter 98 in. long to be tested.

A worm-geared plug valve is used for the rate-of-flow controller to permit very accurate control and also to eliminate any danger of slamming, which is possible when a plug valve is operated in a partially open position. The exposed gears of the control valve are enclosed by a cover plate, on which a quadrant, graduated in quarter turns of the handwheel, has been placed to indicate the position of the plug. Access holes have been provided to allow the alemite grease fittings to be reached. The heavy-duty, buttonhead grease fitting allows the plug to be lubricated with a pneumatically operated, heavy-duty grease gun. This has

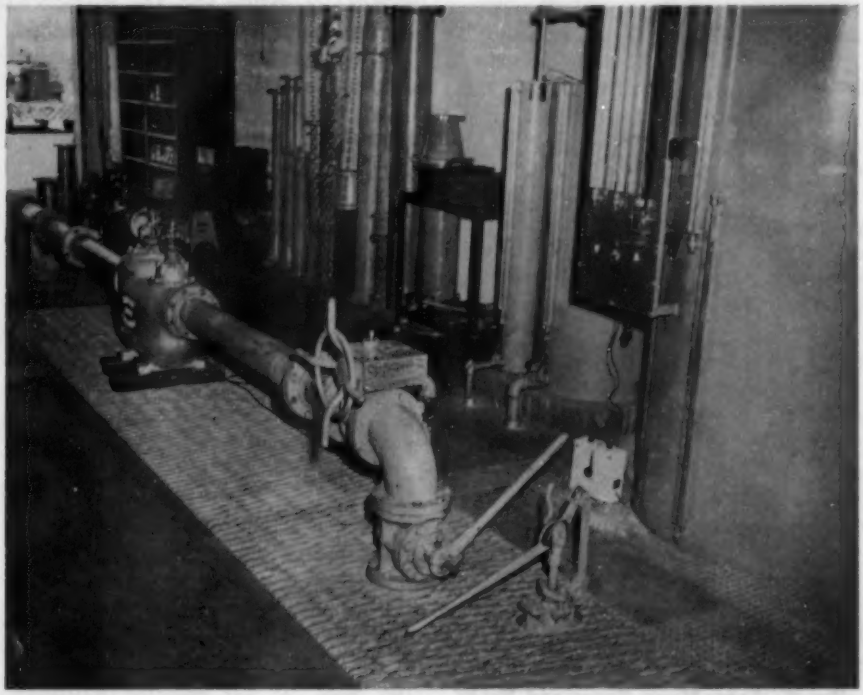

Fig. 5. Large-Meter Tester

This view from the outlet end of the tester shows the handwheel-operated, enclosed, worm-geared plug type throttle valve mounted above the ell. Below the ell is the lever-operated plug used as a shutoff valve. At right can be seen one of the two 150-cu ft tanks, on which the manometer panel is located.

been found very useful, as the valve should be greased frequently to insure easy operation. This valve is connected by a flanged ell to another plug valve, lever operated, which allows the water to be turned on and off at the beginning and conclusion of a test without disturbing the setting of the rate-of-flow control.

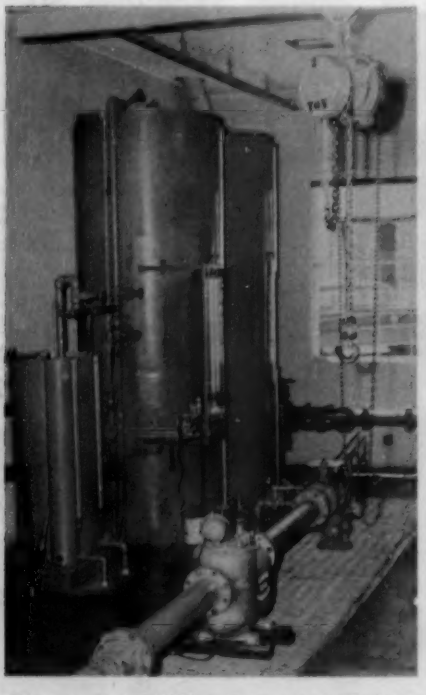

Fig. 6. Large-Meter Tester and Tanks

This view from the inlet end of the tester shows the two small and two large tanks, as well as the overhead crane.

From the shutoff valve, the discharge pipe drops down below the level of the floor and is connected through a true wye to the bottom of two 150-cu ft test tanks, which are 4 ft in diameter and 13 ft in height. Each tank has been designed to allow the water to enter through a 6-in. line located in the center of the conical bottom. The tanks have been connected with plug valves installed in the inlet lines and in a 6-in. equalizing line between the tanks near the bottom. These valves permit rapid changes of gating and are guaranteed by the manufacturer to be droptight.

The water entering the tanks strikes a 30-in. baffle plate, which is mounted on four 4-in. antiswirl vanes welded to the conical bottom. This causes the water to enter with a minimum of turbulence at velocities up to 1,000 gpm. With both tanks in use, it is possible to conduct accurate tests at flow rates up to 2,000 gpm, the maximum flow for which the tester was designed. Each tank has been equipped with three 48-in. gage glasses, calibrated in 5-cu ft intervals. The large left-hand tank in Fig. 6, which is used alone for

Fig. 7. Recording Devices

These patented electrically operated devices are here shown mounted on a 6-in. compound meter.

lower rates of flow, is calibrated individually, while the right-hand tank, which is always used with both tanks connected together for the higher rates, has calibrations showing the total volume in both.

A 2-in. section at the top rear of each tank has been cut away to allow the water to spill over in back and fall harmlessly into the pit, if, for any reason, the water cannot be shut off in time to prevent the tanks from overflowing. A stationary ladder is installed between the tanks and a folding platform is provided for use in inspections of the inside of the tanks, adjustment of the electrodes, and observation of the entry of water.

Each of the tanks is equipped with three electrodes connected to a selector switch that makes it possible to conduct tests using 50, 100, or 200 cu ft of water. The left-hand tank can measure a 50-cu ft volume between the 25- and the 75-cu ft levels or between the 75- and 125-cu ft levels; 100-cu ft volumes are measured between the 25- and 125-cu ft levels. The electrodes in the right-hand tanks are spaced to allow the measurement of 100 cu ft between either the 50- and 150-cu ft levels or the 150- and 250-cu ft levels: 200-cu ft volumes are measured between the 50- and 250-cu ft levels.

Flow rates from 0.25 to 25 gpm are measured in two smaller tanks (Fig. 6) with capacities of 1.5 and 15 cu ft. These are connected to the large tester through a 2-in. line which branches off just ahead of the 6-in. worm-geared throttle valve. The flow to the small tanks is controlled with a quick-closing, solenoid-actuated valve, the rate of flow being shown by a dual-range indicator.

The 2-in. line also runs up over the side of the left-hand large tank and discharges the test water into a 4-in. pipe in this tank. The 4-in. pipe, which is open at both top and bottom, conveys the water to the bottom of the tank in a restricted area, to reduce turbulence to a minimum. This line is used with flow rates at which the dual-range indicator is more accurate than the manometers connected to the venturi tube (described below). Rates of flow up to 175 gpm can be measured through this line, but it is the usual practice to use the 6-in. control valve for rates exceeding 50–75 gpm.

The electrically actuated recording device employed with this tester has been designed to incorporate certain patented features. At the top of the instrument (Fig. 7) is a graduated dial, 6 in. in diameter, with a pointer that is not connected to the shaft beneath. The shaft is set to engage one of the hands on the regular meter register. When the water reaches the lower electrode in the tank, a circuit is closed, actuating a relay that energizes the electromagnetic clutch on the recording device. This causes the upper (recorder dial) pointer to engage the shaft and, thus, to move with the hand of the meter register. When the water reaches the upper electrode, another relay breaks the circuit to the clutch, causing the upper pointer instantaneously to cease moving, although the water continues to flow through the meter and the meter register continues to operate.

A 6×3.98-in. venturi tube is installed in the inlet piping to the tester. Connected to the venturi are two single-leg manometers to indicate the rates of flow. The manometers are mounted on a panel located on the left-hand side of the large tanks (Fig. 5),

directly in front of the person making the test. One manometer contains mercury and has a range of 0–2,000 gpm. The second, installed in parallel, contains a fluid with 1.81 sp gr, which accurately indicates flows up to 500 gpm. An electrical timer records the exact period required for a given volume of water to pass through the tester. This makes it possible to determine the rate of flow more accurately than the dual-range indicator or the manometers permit.

A buzzer begins to sound when the water has reached the upper electrode, continuing until the circuit is broken by the closing of the wrench-operated, plug type shutoff valve. The latter is equipped with a microswitch so mounted that it will break the circuit when it is in the completely closed position.

A third manometer measures the head loss across the meter through the use of piezometer connections in the inlet and outlet adapters. These taps have been located so as to have a minimum of eight diameters of straight pipe ahead of each tap to insure accurate readings. The hose connections have been provided with quick-disconnecting fittings.

An overhead crane (Fig. 6), used to handle the large meters and connecting piping, consists of two parallel rails that run the width of the building over the meter tester. A chain hoist, with a capacity of 2 tons, is mounted on a transverse rail, allowing an area of 14 × 50 ft to be covered. A doorway at one end of the shop is large enough for a truck to back through, so that the meters can be lifted directly from it.

Conclusion

In the design and construction of new facilities for the repair and testing of large and small meters at Long Beach, every effort has been made to follow the principles of efficient material handling, to use proper equipment and tools, and to insure the health, safety, and comfort of the workmen. Throughout the entire program, employees were encouraged to offer suggestions regarding the layout and equipment of the shop. Wherever possible, these ideas were incorporated in the final design.

Inasmuch as Long Beach is a rapidly growing city, very careful consideration was given to the possibility of expanding the meter shop to meet future needs for many years to come. At present the water department serves a population of approximately 300,000, through approximately 63,000 meters in sizes from ¾ in. to 2 in. and 300 in sizes from 3 in. to 10 in. If it should prove necessary to expand the meter shop facilities further, space can readily be made available by the relocation of adjoining shops.

Economics of Meter Repair Program at Tuscaloosa

E. E. Love

A paper presented on Oct. 27, 1954, at the Alabama-Mississippi Section Meeting, Birmingham, Ala., by E. E. Love, Asst. Supt., Water Works Dept., Tuscaloosa, Ala.

IN 1952 the Tuscaloosa, Ala., Water Dept. had approximately 11,000 customer meters, about 2,000 of which had stopped or were not registering. A repair program was instituted, beginning with meters 2 in. and larger. Next it was intended to repair the smaller meters, taking one section of the service area at a time, but it soon became evident that this method would require a long period to eliminate the major registration losses, unless additional help were hired. Consequently, the plan was changed. All the meter books were checked to locate the stopped meters of customers who were believed to be using excessive amounts of water. It was estimated that the additional revenue realized from the repair of these meters would be greater than the saving in repair cost that a section-by-section program would have offered.

After the meters of excessive users had been fixed, the remaining defective ones in the system were repaired on a sectional basis. As a complete overhaul in the shop took too long a time, in view of the number involved, a speedier procedure was adopted. Nonregistering meters were removed to the shop only if the disc had stopped; otherwise, the register, gear wheels, and glasses were replaced as needed, on the customers' premises, without regard to the length of service of the meter. This procedure undoubtedly permitted some underregistering meters to remain in use, but the objective of getting stopped meters to register as soon as possible was achieved.

The following figures show how important it is to keep every meter registering: in 1951 the revenue per million gallons collected by Tuscaloosa was $158.53, while in 1953 it was $167.07; this increase of $8.54 per million gallons amounted to approximately $25,000 a year. It can readily be seen that the cost of meter repairing is quickly returned in revenue gained. As there was still a considerable number of stopped or underregistering meters in service in 1953, a further sizable increase in revenue is anticipated when the program has been completed.

Meter removal and replacement is carried out by the meter readers during a period of 8–10 days each month. Testing and repair in the shop is done by one man, with a helper most of the time. The repairman is also in charge of the shop and stockroom, keeps inventory, and issues supplies to water works crews. In 1953 a total of 3,795 meters were tested and repaired in the shop; at the meter location, 1,263 registers were replaced or repaired and 1,917 glasses were replaced. In July 1954 Tuscaloosa had 12,000 meters, none of which had been stopped more than 30 days. It is expected that the rate of stoppage, which was about 100 a month in September 1954, will be

greatly reduced in the future as the condition of all meters in the system is improved. The repair cost per meter should also decrease somewhat.

Since 1952 the average cost of parts and material per meter repaired has been $3.65; for meters with registers replaced or repaired, the cost has averaged $0.68. Shop labor costs are difficult to calculate because of the numerous other duties of the repairman. A further expense is the investment in parts inventory and testing equipment. Aside from the practical utility of the tester, there is a great deal of public relations value in being able to assure customers that their meters have been checked accurately.

Test and Inspection Plan

A comprehensive meter test and inspection program is now under way at Tuscaloosa. A card filed for every meter will list its number, preinstallation test data, date and location of installation, date and cause of removal, parts used for repair, postrepair test data, location and date of reinstallation, and remarks. A duplicate listing of all meters larger than 2 in. is maintained in a separate meter book. Such meters are to be inspected every 90 days, with a record of the reading and of the condition of the meter, gears, and register. It is planned to remove, clean, and test all small meters that have been in service 10 years or longer. The same will be done for meters with damage to the glass or register, if they have been in service more than a year; for those with less service, the glass or register may be replaced at the meter location. No meter will be permitted to remain stopped longer than 30 days.

Water Conservation Through Metering

George A. Granger

A contribution to the Journal by George A. Granger, City Mgr., Big Rapids, Mich.

THE public water supply of Big Rapids, Mich., is obtained from the Muskegon River, which flows through the city, dividing it into two almost equal parts. Until 1921 raw river water was pumped to town without treatment. As this supply was known to be unsafe, privately owned wells provided much of the drinking water. The almost continuously high typhoid fever incidence formerly experienced by the city is stark evidence that some citizens imbibed the river water and perhaps most used it for washing and teeth brushing. The quantity of water pumped was exceptionally large and varied little between winter and summer. This condition was due to cheap pumping costs (water power actuated the pumps), the use of untreated water, and flat rates. Pumpage usually exceeded 5 mgd for a population that was approaching 5,000.

In 1921 chlorination was established under the control of a local laboratory. Both treatment and control proved in-

adequate to stem completely the incidence of typhoid fever. In 1937, at the insistence of the Michigan Dept. of Health, a modern water filtration plant was built, with a rated capacity of 2 mgd. The plant was completed in the summer of that year but could not be placed in service until the fall, when the water demands of the town were within its capacity.

The city commission, anticipating water deficiencies, requested permission to augment the filtered supply with raw river water to meet the next summer's demands. As this permission was denied by the State Dept. of Health, the commission reluctantly ordered all industrial and commercial services to be metered. When the author came to Big Rapids, in 1947, the town was about half metered and the output of the treatment plant was at peak capacity—slightly more than 2 mgd, summer and winter.

Within a year, metering (¾–4-in. sizes) was completed for all of the 1,500 services, and more accurate records of water produced and delivered could be kept. Almost immediately, it was apparent that unaccounted-for water totaled 60–70 per cent, indicating that somewhere in the system there were huge leaks. An organized search disclosed leaks by the dozen, most of them quite large. One was a split main discharging into an 8-in sanitary sewer. Repair of this single leak reduced the pumpage by 0.4 mgd. By the end of 1949 less than 0.5 mgd was being treated, on the average, and the minimum was 0.3 mgd.

This tightening up of the system made it possible to plan a general overhaul. A bond issue for about $250,000 was approved, enabling the building of a new 300,000-gal elevated tank, the laying of 2 miles of new mains, and the conversion of the pumping station to automatic operation at double the previous capacity. This work was completed in July 1952.

Other improvements since that time have included the acquisition of new laboratory equipment, a modern alum feeder, and a second chlorinator. In the summer of 1953 a valve-inserting machine made it possible to put fifteen valves in under pressure. Small sections of the system can now be shut down without affecting many water users.

Completion of metering and all the other improvements has contributed to increased efficiency in the water system. Records during 1953 and 1954 show an unaccounted-for water range of 6–20 per cent, depending on the time of the year. That is quite a difference from the 60–70 per cent of 6 years ago.

The current total yearly production is 221 mil gal. The static pressure throughout the business areas is 60 psi, while pressure in the residential section varies from a low of approximately 30 to a high of 50 psi, depending on location. Waterborne typhoid fever has long since vanished from the city.

Vacuum Degasification of Water for Taste and Odor Control

Bernard Schiller

A paper presented on Oct. 28, 1954, at the California Section Meeting, Long Beach, Calif., by Bernard Schiller, San. Engr., Indenco Engrs., Inc., Oakland, Calif.

THE drilling of wells on the seaward portion of the Los Angeles coastal plain involves a certain amount of risk as far as the quality of the water in the well is concerned. Wilson (*1*) describes the changes that take place in the chemical characteristics of the ground waters in this area due to the influence of basic conditions, industrial-waste pollution, and salt water intrusion as one proceeds from the mountains to the sea. Industrial wastes and salt water intrusion have led to the abandonment of many wells, but, in general, problems caused by the basin influence have been adequately handled by proper water treatment. The basin influence problems requiring quality control consist of color, sulfides, methane, carbon dioxide, and slime-forming organisms.

General Considerations

The decision of the Southern California Water Co. to drill its Athens No. 1 well was made because the advantages of its strategic location were believed to outweigh the risk which a careful study had shown to exist. The geologic investigation had indicated that the well would be located in, or in very close proximity to, the Inglewood fault zone, and, judging from samples of wells in the immediate vicinity, it appeared that sulfides probably would be present. The treatment of sulfides in several of the other company wells, however, had presented no great difficulty. The sulfide content in the latter, although enough to be a taste and odor problem, was generally less than 1 ppm.

The Athens well water proved to be similar to other waters in the area, except for the sulfide and methane content. The water contained 6 ppm of sulfides, expressed as H_2S, and sufficient methane to produce 1 cu ft of the gas at atmospheric pressure for every 21 cu ft of water pumped. If the sulfides and methane could be successfully removed, the water could be used for domestic purposes. The well also produced sand, a problem that would have to be considered in any final design. Preliminary experiments indicated that the sand could be removed by the use of a trap.

The removal of methane from water requires only aeration and dispersal or dilution of the removed gas to avoid an explosion hazard. The removal of sulfide is usually accomplished by aeration and chlorination or by chlorination alone. As it is impossible to remove all the sulfides by aeration, an oxidizing agent like chlorine is used to complete the process.

Sulfides are present in water as metallic salts and as hydrogen sulfide. The percentage of each is dependent upon the pH of the water; the lower the pH, the larger the percentage of hydrogen sulfide. Pomeroy (*2*) indicates that, at pH 5.0, 98 per cent of the sulfides is in the form of hydrogen sulfide, whereas, at pH 8.0, only 5 per cent of the sulfides is in this form.

Hydrogen sulfide is released as a gas upon aeration, while the metallic sulfides are oxidized by the oxygen, forming sulfate and free sulfur. The latter, if in sufficient quantity, gives the water a milky appearance and must be removed by filtration.

Chlorine oxidizes sulfide to free sulfur and sulfate (*3*), in accordance with these two equations:

$$Cl_2 + S^{--} \rightarrow 2Cl^- + S$$
$$4Cl_2 + S^{--} + 4H_2O \rightarrow 8HCl + SO_4^{--}$$

From the standpoint of the water plant operator, the oxidation to sulfate would be ideal when a high sulfide content is encountered; no means has been found to control the reaction, however, and free sulfur is invariably formed.

Samples of water from the Athens No. 1 well indicated that neither aeration nor chlorination, singly or in combination, would produce a clear effluent. Some other method of treatment would have to be found, or else a filtration plant would have to be built to produce a satisfactory water.

Pilot Plant Study

It was decided to make pilot plant studies of all possible means of treatment in order to determine the most economical. The initial pilot plant consisted of an aerator and a chemical feeder. As the experiments progressed, the original pilot plant was expanded by the addition of a gravity holding tank, a pressure mixing tank, a pressure iron filter, a pressure carbon filter, more chemical feeders, and a pressure aerator. The well was pumped at full capacity during the entire pilot plant study to simulate normal conditions of operation, and the required pilot plant water was taken from the well discharge line before the pressure was released. The major portion of the pumped water was wasted.

The results of the first set of experiments proved unsatisfactory, as the following observations indicate:

1. *Aeration only.* No method of aeration—cascade, forced-draft, or diffused-air—proved effective. All the methane appearing and some of the sulfides were removed, but the water always turned milky.

2. *Aeration followed by chlorination.* An attempt to control the aeration to remove only the methane and then to oxidize the sulfides with chlorine proved a failure. Simply releasing pressure in a small tank liberated the methane and some of the sulfides as hydrogen sulfide, but enough oxygen was absorbed on the surface to oxidize a sufficient quantity of the remaining sulfides to form a slightly milky water. The oxidation of the remaining sulfides with chlorine produced more free sulfur.

3. *Chlorination followed by aeration.* Chlorine was applied in sufficient quantities to assure the oxidation of all the sulfides while the water was under pressure, and the chlorinated water was held under pressure for various periods. The chlorinated water was then aerated to remove the methane.

The end product again was milky water. It is interesting to note that the chlorinated water did not turn milky until the pressure was released. This method was tried because in another plant sulfides were successfully removed from a well pumping directly into a hydropneumatic tank. Chlorine was applied to the turbine discharge and, although an air cushion was maintained in the tank, no milky water resulted. Experiments made at that well, however, showed that aeration or chlorination at atmospheric pressure produced milky water. Apparently the tendency toward the oxidation of the sulfides to sulfates is greater at pressures above atmospheric than at atmospheric in this well. The extent of this reaction was not investigated.

4. *Chlorine dioxide.* Substitution of chlorine dioxide for the chlorine used in the previous experiments produced no better results than did the chlorine.

5. *Sodium hexametaphosphate.* At another plant of the Southern California Water Co., sodium hexametaphosphate was used successfully to avoid milky water where sulfides were removed by aeration and chlorination. This chemical was tried at the Athens well in various combinations with chlorine and air and was found successful, but the dose of hexametaphosphate required was too high to be practicable.

6. *pH control.* At pH 7.9, the pH at which the water came from the well, 6 per cent of the sulfides was in the form of hydrogen sulfide, and aeration removed about 30 per cent of the total sulfides. It was felt that, if the pH were lowered, more of the sulfides would be removed by aeration as hydrogen sulfide, leaving less to be oxidized by the oxygen and possibly avoiding milky water. This theory did not work out as expected, because, at pH 6.0, when 84 per cent of the sulfides was in the form of hydrogen sulfide, aeration removed only 70 per cent of the total sulfides and produced milky water.

Thus far, all attempts at oxidation had failed to produce a water good enough for domestic use. A means other than oxidation would have to be found to remove the sulfides if milky water or further treatment was to be avoided.

7. *Pressure iron filter.* The water was passed through a bed of steel wool to try to form an insoluble sulfide. The sulfides were completely removed in the form of iron sulfide, but the water picked up so much iron in solution that a new treatment problem was introduced. Iron filings, turnings, and cast-iron chips gave no better results.

8. *Pressure carbon filter.* The water was filtered through a bed of granular activated carbon. This successfully removed the sulfides, but the methane quickly fouled the carbon bed, rendering it useless. The methane adhered to the carbon granules and soon formed such large bubbles that a 2¾-in. filter would not pass any water. It appeared that a way had been found to remove the sulfides without causing milky water, but, before it could be used, the methane had to be removed.

9. *Aeration under pressure.* The water was aerated under pressure by injecting a very small volume of air through a diffuser. It was believed that it might be possible to jar the methane loose, but, instead, the air oxidized the sulfides and even excess air did not release the methane. This proved that the pressure had to be reduced to atmospheric before the methane could be removed.

Vacuum Degasifier

The idea of releasing the pressure under a gas that would not oxidize the sulfides was considered, but the attendant operational problems and volumes required to offset the explosion hazard proved too costly for further experiments. These findings led to the study of a vacuum degasifier.

A pilot plant vacuum degasifier was built. It consisted of an 11-ft section of 14-in. pipe set vertically, with the inlet at the top and the outlet at the bottom. By means of a gage glass, the free fall of the water could be maintained between 6 and 9 ft. To break up the water, the degasifier was filled with rock. To carry the water away, a positive-displacement pump was used, driven by a gasoline engine, so that different rates of flow could be maintained. An electrically driven laboratory vacuum pump was used to maintain the vacuum. A ¼-in. needle valve allowed air to be bled into the vacuum pump suction to maintain the desired vacuum, and a mercury column was installed in the side of the tank to measure the vacuum. The whole apparatus was equipped with the required valves, a chemical feeder for pH control, and a pressure mixing tank to assure the proper mixing of the acid.

Experiments were run under various conditions. The flow through the degasifier was varied from 1 to 10 gpm per square foot, the vacuum from 16 to 26 in. of mercury, the drop from 6 to 9 ft, and the pH from 7.9 to 6.0. The effluent was checked for methane, sulfides, and pH. Part of the effluent was dosed with chlorine, and part was passed through a granular activated-carbon bed.

Conclusions

Certain facts were established, but insufficient time was available for a complete evaluation of all the factors involved in the removal of the methane and sulfides from this water.

1. Complete methane removal was attained at a flow of 10 gpm per square foot with a vacuum of 16 in. of mercury, the maximum evacuation tried.
2. The lower the rate of flow, the more sulfides were removed, at the same vacuum.
3. The greater the evacuation, the more sulfides were removed, at the same rate of flow.
4. Lowering the pH increased the removal of sulfides, all other conditions being equal.
5. More sulfides were removed by the vacuum degasifier than by aeration at the same pH.
6. The effluent of the degasifier was never milky.
7. In all tests, the pH of the effluent was increased, indicating the removal of carbon dioxide, as well as hydrogen sulfide and methane.
8. Falls between 6 and 9 ft were investigated. Although the greater fall produced slightly better results, the economics of the height of fall were not determined.
9. Chlorine could be successfully used to oxidize the sulfides in the effluent, provided that they did not exceed 0.5 ppm.
10. A granular activated-carbon filter removed all traces of sulfide from the degasifier effluent, regardless of the quantity of sulfides present, with no trace of milky water. Time was not available to determine the length of run of the carbon filter, the effect of backwashing, or the effect of regeneration of the activated carbon.

The vacuum degasifier can be a useful tool in the control of tastes and odors caused by a high sulfide content in water. The degasifier, with or without pH control, is not, in itself, the complete answer. Chlorination, alone or in conjunction with an activated-carbon filter, is needed to complete the treatment.

Acknowledgment

The author would like to express his appreciation to C. P. Harnish, Pres., and L. J. Alexander, Chief Engr., Southern California Water Co., Los Angeles, for making this study possible and for their help and guidance; and to Carl Wilson, Consultant, Los Angeles, for suggestions that aided materially in performing this study.

References

1. Wilson, Carl. Geochemical Alterations in Ground Waters of the Los Angeles Coastal Plain. *Jour. AWWA*, **39**:423 (May 1947).
2. Pomeroy, Richard. Hydrogen Sulfide in Sewage. *Sew. Ind. Wastes*, **13**:498 (1941).
3. Black, A. P. & Goodson, J. B., Jr. The Oxidation of Sulfides by Chlorine in Dilute Aqueous Solutions. *Jour. AWWA*, **44**:309 (Apr. 1952).

Revision of Steel Pipe Flange Specifications

The AWWA Board of Directors has approved the following changes in Tables 1, 2, and 3 of the Tentative Standard Specifications for Steel Pipe Flanges—AWWA C207–52T:

a. Flange dimensions have been added for intermediate pipe sizes (38, 40, 44, 46, 50, and 52 in.) in all three tables.

b. The second note under Tables 1 and 2 has been revised to point out that bolt diameters for Class B, in sizes greater than 48 in., do not conform to ASA B16b2 (25-psi cast-iron standard).

Study of High-Rate Filtration at the Dalecarlia Plant, Washington

Norman E. Jackson

A paper presented on Oct. 28, 1954, at the Chesapeake Section Meeting, Baltimore, by Norman E. Jackson, Chief, Dalecarlia Section, Water Supply Div., Washington Dist., US Army Corps of Engrs., Washington, D.C.

FILTRATION of water at high rates has received continued attention over the past decade, with increasing interest being manifested in the last few years. A brief review of recent literature on the subject indicates that there is much to support a raise in design rates from the normally accepted value of 2 gpm per square foot. Baylis (*1*) stated in 1949 that, assuming there is no sacrifice of water quality, a reduction in filter cost can be gained by operating at elevated rates, as the filter size can be reduced. He has substantial data (*2*) to show that excellent water quality can be maintained at high rates through the use of floc-strengthening aids and close control of water treatment. Economy may be gained through reduction in the size of filters but not necessarily in the effluent piping and the rate controller, where considerable head is lost at high rates. These appurtenances should be carefully designed if high rates are to be used.

Hazen (*3*), in a 1953 discussion of the elements of filter design, also placed emphasis on the necessity for good control of pretreatment and adequate supervision at high rates. He pointed out that the chances of providing such supervision in smaller plants, or in plants where sudden changes in raw-water quality are likely, were not good, in general, and that the safety factor involved was much lower than elsewhere. The fact that heavy dosages of carbon, which are necessary in some plants for taste and odor control, may pass to the clear well is a deterrent to operation at high rates. In such circumstances, it might even be found preferable to design more filters at the conventional rate of 2 gpm per square foot. In a review of the data on several recently designed filters, Hazen found that higher rates are being used in some plants, particularly the larger ones, while most plants are still holding fairly close to 2 gpm as a normal rating.

Cox (*4*), in a 1953 article on high-rate filtration, also stressed pretreatment. Great care should be exercised to design each plant keeping in mind the local conditions and water characteristics, as well as the kind of supervision available and the factors of safety involved, rather than proceeding to adopt higher rates without supporting data. Cox concluded that, in order to operate economically and effectively at rates in excess of 2 gpm per square foot, a plant should be designed as a whole to insure effective flocculation and sedimentation at all times. He indicated that a trend toward high

rates as standard practice would be unfortunate, unless the economy of high-rate filtration were fully justified by adequate engineering studies.

Qualified opinion apparently agrees, then, that design rates higher than 2 gpm could safely and economically be used in a particular locality, provided that sufficient engineering data and proper study justify the choice and that all relevant factors are integrated in construction to accomplish the purposes of the design. Furthermore, it is evident that adequate supervision of operation is a necessity.

The current interest of Washington Aqueduct operating personnel in filter rates began when six new filters were placed in service at the Dalecarlia Plant in April 1952. It was desired to learn which of several types of underdrains demonstrated the best hydraulic characteristics at various rates of filtration. In addition, information was needed on the accuracy of the table gages, the performance of the rate controllers, and the action of the anthracite medium in conjunction with the underdrains of the new filters.

Prior to this time it had been observed that considerable head loss occurred through the rate controller mechanism of the old filters under high summer demands. It had been established that a large portion of the head loss could be eliminated and filter output increased by replacing this mechanism with a more efficient means of controlling the flow. Thus, it seemed advantageous to investigate, under similar conditions, the six new filters and selected units of the old filters, in two of which, for test purposes, the rate controller mechanism was replaced by a straight pipe. Operation of the filters at high rates was one of the principal conditions of this test.

General Information

The Dalecarlia Filter Plant, which is operated by the Water Supply Div. of the Washington Dist., US Army Corps of Engineers, is the rapid sand component of the treatment facilities of the District of Columbia. It has a rated capacity of 109 mgd, based on 26 filters, each carrying a nominal rating of 4 mgd. When originally constructed in 1927, the plant contained 20 filters. As previously mentioned, six new filters, constructed under the current expansion program, were placed in service in April 1952. Initially, the old filters were equipped

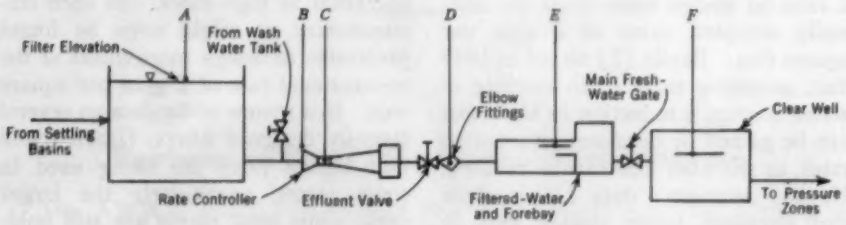

Fig. 1. Schematic Diagram for Filter Performance Tests

The filters were equipped with manometers, and elevations were read at the points indicated by letters A–F.

with sand, but, over the years, conversion to anthracite has been carried out. As of October 1954, sixteen filters, including the six new ones, employ anthracite, and ten use sand.

The Potomac River at Great Falls, Md., is the source of the raw-water supply. Industrial- and domestic-waste pollution at this point is not serious, and turbidities, which at times reach rather high levels (1,250 ppm was the maximum treated since 1950), are, on the average, not excessive. The average turbidity treated in 1953–54 was 49 ppm. The water is medium hard, averaging about 100 ppm as calcium carbonate. Natural alkalinity, averaging 65–70 ppm as calcium carbonate, has always proved sufficient for coagulation requirements. Plankton are troublesome at times but usually do not constitute a serious problem.

The general pattern of treatment given raw water entering the plant consists of superchlorination followed by the application of liquid aluminum

TABLE 1

Turbidity and Bacteriological Data

Date and Run No.	Water Temp. °F	Filter No.	Initial Filter Rate *gpm/sq ft*	Order of Turbidity to Filters *ppm*	Filter Effluent Initial Turbidity *ppm*	Bacteriological Data			
						37°C Count (Max.)		MPN (Max.)	
						To Filters	Filter Effluent	To Filters	Filter Effluent
10/28/52	50	3	5.0	2.6	0.6	2	2	0	0
Part 1		9	5.0	1.4	0.3	2	1	0	0
Run 1		22	4.0	2.6	0.7	2	1	0	0
		24	4.0	2.5	1.5	2	1	0	0
6/3/53	70	3	5.0	1.0	0.4				
Part 1		9	5.0	1.0	0.2				
Run 1		22	4.0	1.0	0.2				
		24	4.0	1.0	0.1				
6/3/53	70	22	3.0	12.0	1.2				
Part 2		24	3.0	12.0	2.8				
Run 2						3*	5*	0*	0*
6/9/53	70	22	4.0	1.9	0.1				
Part 2		24	4.0	1.9	0.5				
Run 3									
6/12/53	70	22	2.0	1.4	0.0				
Part 2		24	2.0	1.4	0.6				
Run 4									
10/14/54	72	22	4.5	0.0	0.4				
Part 3		24	4.0	0.0	0.15	12†	4†	0†	0†
Run 1									

* Maximums for plant operation during period Jun. 3–19, 1953.
† Maximums for plant operation during period Oct. 14–19, 1953.

sulfate (17 per cent Al_2O_3) for coagulation. No floc-strengthening agents are used at present. Flocculators are employed for floc growth, followed by 4–5 hr of sedimentation at nominal flows. Sulfur dioxide is used for taste and odor control. Sufficient chlorine capacity is maintained for pretreatment, intermediate treatment, and post-treatment of the raw water. Fluoride is added as a dental health measure, and lime is used for pH adjustment of the water, as a last step in conditioning before storage in the clear well.

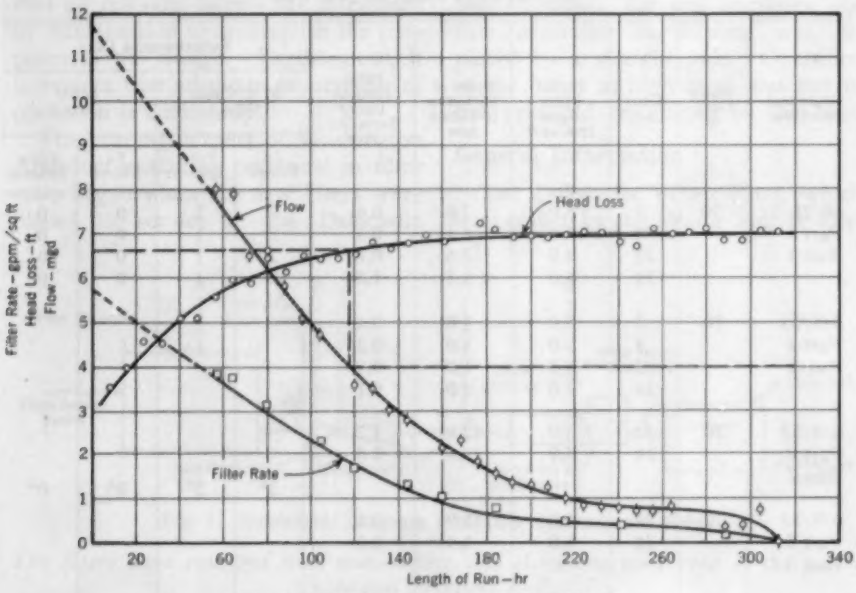

Fig. 2. Performance Data, Filter No. 3

Test conditions: rate controller mechanism removed; 4-in. cast-iron laterals with brass ferrules; graded gravel and anthracite (0.72-mm effective size); water temperature, 50°F; continuous run.

Description of Filters

Of the four filters (No. 3, 4, 9, and 12) chosen to start the tests, No. 3 and 9 had the rate controller mechanism removed. All of the filters tested are equipped with perforated cast-iron lateral underdrains, with brass-lined perforations, except No. 9. Graded gravel supported the medium in each filter—about 20 in. of anthracite in No. 3 and 12 and about 15 in. of sand in No. 4 and 9. Each filter is rated at 2 gpm per square foot, has 1,452 sq ft of area, and is considered a 4-mgd unit.

When the six new filters were constructed, four (No. 21, 24, 25, and 26) were equipped with perforated-tile underdrains, one (No. 22) with a porous-plate underdrain, and one (No. 23) with a perforated asbestos-cement lateral underdrain. Thus, different

types of underdrains could be observed in operation, and data could be gathered to delineate the advantages and disadvantages of each. All except Filter No. 22 were equipped with graded gravel and 24 in. of anthracite, while No. 22 utilized only anthracite, to a depth of 31 in., as the filter medium. Like the old filters, each of

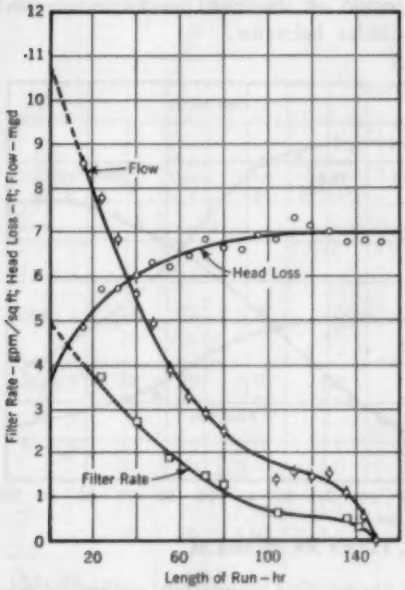

Fig. 3. Performance Data, Filter No. 9

Test conditions: rate controller mechanism removed; 4-in. cast-iron laterals without brass ferrules; graded gravel and sand (0.52-mm effective size); water temperature, 50°F; continuous run.

the new ones was designed with a nominal rating of 2 gpm per square foot (4 mgd, based on an area of 1,425 sq ft).

Both the old and the new filters have the standard table gages for flow and loss of head. All the filters are equipped with Palmer rotary sweeps for surface wash. The backwash rate is indicated by a meter graduated in inches of rise per minute. Sand expansion is not routinely measured but is controlled through the rate of backwash. For measuring head losses and flows in the test, the filters were equipped with manometers, and elevations were read at the points indicated on the schematic diagram shown in Fig. 1.

Test Methods and Results

In order to develop the information required, it seemed desirable to divide the gathering of data into four general parts. These parts will be outlined and the results dealing with high-rate filtration discussed. Comments and comparisons will be confined mostly to filters No. 3, 9, 22, and 24.

Part 1

In the initial test, old filters No. 3, 4, 9, and 12 and new filters No. 21–26 were operated under high-rate conditions by providing sufficient head differential between the outlet of the sedimentation basins and the clear well to produce an initial rate of approximately 5 gpm per square foot on filters No. 3 and 9 and approximately 4 gpm on No. 21–26. This differential was maintained as nearly constant over the test run as plant operations and pumping requirements permitted. Rate controllers on all filters were wide open, to allow maximum filtration rates. All filters were kept on the line until they ceased producing at maximum head loss. Samples for turbidity and bacteriological analysis were collected initially and at 8-hr intervals thereafter, for the extent of the run. After a test filter had been removed from the line,

it was backwashed; the wash water requirements were noted; and the bed expansion data were observed at the maximum backwash rate.

High initial rates of filtration did not have as pronounced an effect on the anthracite filters as on the sand, as may be seen in Fig. 2 and 3, which compare filters No. 3 and 9. Filter No. 3 was not down to its nominal rating of 4 mgd until about 120 hr, whereas No. 9 reached the same point in approximately 50 hr. The relationship of flow, filtration rate, and length of run for anthracite of 0.72-mm effective size is compared with that for sand of 0.52-mm size in Fig. 2 and 3 for similar filters tested under similar conditions. It is recognized that a completely objective comparison of the performance of anthracite and sand cannot be drawn here because of the difference in effective sizes on the test filters. As similar sizes were not available, however, the results are presented for evaluation under the conditions outlined. Figure 4 shows the same factors for filters No. 22 and 24, with the same medium but different underdrains. The initial filter rate and head loss were somewhat higher on No. 22 than on No. 24, but over the period of the run the filters showed similar behavior.

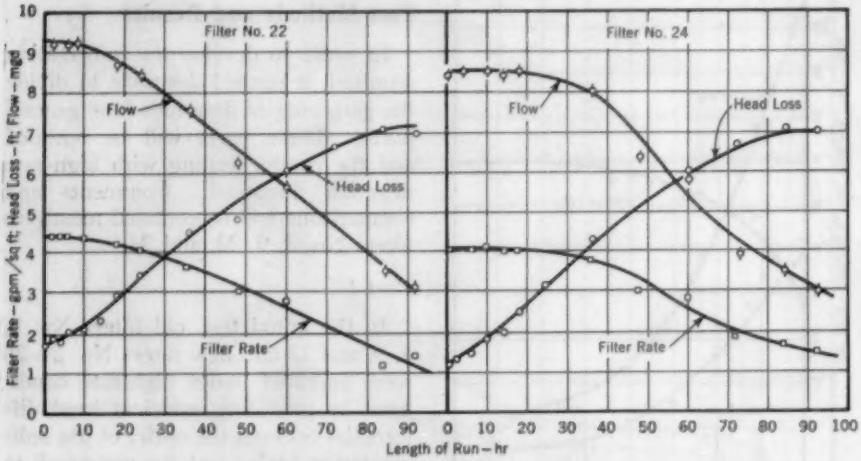
Filter No. 22
Filter No. 24
Flow
Head Loss
Filter Rate
Filter Rate – gpm/sq ft; Head Loss – ft; Flow – mgd
Length of Run – hr
0 10 20 30 40 50 60 70 80 90 100

Fig. 4. Performance Data, Filters No. 22 and 24

Test conditions, No. 22: rate controller open; porous-plate underdrain; anthracite medium only (0.76-mm effective size); water temperature, 72°F; continuous run. Test conditions, No. 24: rate controller open; perforated-tile underdrain; graded gravel and anthracite (0.72-mm effective size); water temperature, 72°F; continuous run.

Figure 5 indicates the inability of existing filters and underdrains designed for 2 gpm per square foot to handle initial rates of 5–5.5 gpm with anthracite and 4 gpm with sand. Filters No. 3 and 9 (Fig. 2 and 3) both produced high rates, but at the expense of high head loss. When performance is expressed as rate of flow per foot of head loss, it is evident from

Fig. 5 that, even with anthracite, such rates take their toll in early reduction of output. Another approach is to compare the area under the two curves in Fig. 5 between any time limits. This area, which represents the quantity of flow per foot of head loss during a given period, is smaller for the sand filter (No. 9) than for the anthracite filter (No. 3). Applying the same comparison to filters No. 22 and 24 (Fig. 6)—with the same filter medium as No. 3, but with different underdrains; with the rate controller in place, although open; and with rates of about 4 gpm per square foot—it may be seen that, over the period of the run, No. 22 and 24 would produce more water at reduced initial rates.

TABLE 2

Performance Data

Date and Run No.	Filter No.	Water Temp. °F	Flow Rate *mgd*	Filter Rate *gpm/sq ft*	Flow Period *hr*	Water Produced *mil gal*	Head Loss—*ft*			Performance per Foot Increase in Head Loss *mil gal*
							Initial	Final	Increase	
Jun. '53 Part 2										
Run 2	22	70	6.2	3.0	72	18.6	0.89	3.83	2.94	6.34
	24		6.2	3.0	66	16.9	0.66	3.66	3.00	5.63
Run 3	22	70	8.10	4.0	26	8.75	1.21	2.53	1.32	6.60
	24		8.52	4.0	22	7.80	1.19	2.67	1.48	5.26
Run 4	22	70	3.75	2.0	75	11.70	0.53	3.83	3.30	3.52
	24	70	3.90	2.0	75	12.20	0.50	4.91	4.41	2.76
Run 5	22	70	3.20	1.5	58	7.70	0.33	2.18	1.85	4.20
	24	70	3.80	2.0	42	6.55	0.52	1.95	1.43	4.57
Oct. '53 Part 3										
Run 1	22	72	9.00	4.5	24	9.00	1.76	3.43	1.67	5.38
	24	72	8.51	4.9	24	8.51	1.23	3.10	1.87	4.55

Table 1 shows that the quality of the water produced by the test filters in Part 1 did not suffer under these high rates. The turbidities given establish the order of values observed in the filter effluents. Numerous readings were taken on the effluent waters, and, in general, the turbidities were well below 1 ppm. As turbidities up to 10 ppm are acceptable, according to US Public Health Service standards, there appears to be an ample factor of safety in this respect, if high standards of pretreatment are maintained.

The bacteriological data gathered proved to be of little significance, because the water to and from the filters is practically sterile. There were consistently low counts at both points, and at all times the MPN was zero. The data did indicate, however, that bacteria were not being drawn from

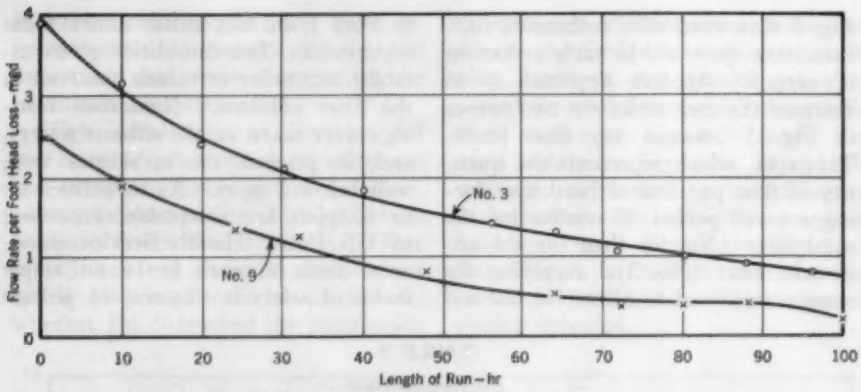

Fig. 5. Flow Rate–Head Loss Ratio Versus Length of Run (Filters No. 3 and 9)

Range of filtration rates: 5.5–2.4 gpm per square foot for No. 3, 4.0–1.7 gpm per square foot for No. 9. Other conditions as in Fig. 2 and 3.

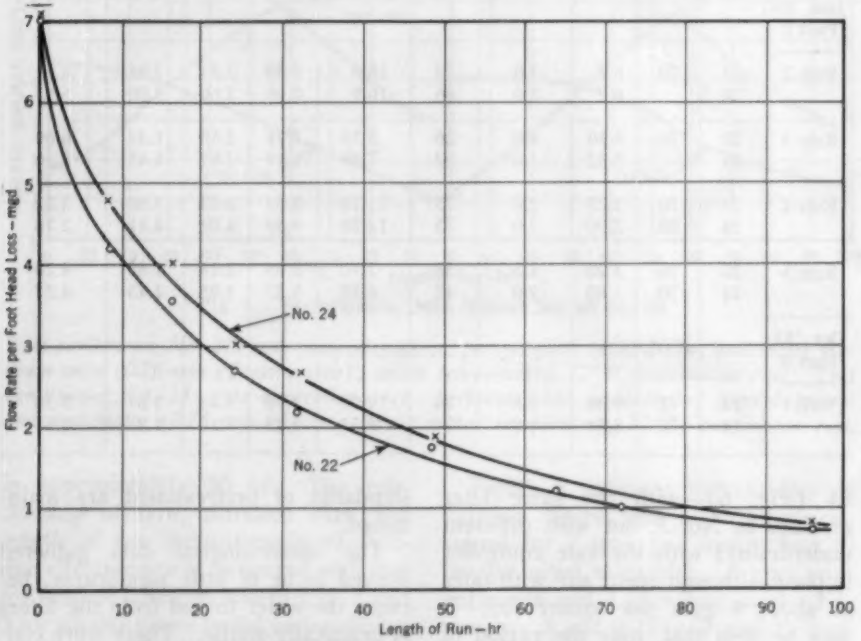

Fig. 6. Flow Rate–Head Loss Ratio Versus Length of Run (Filters No. 22 and 24)

Range of filtration rates: 4.1–0.7 gpm per square foot for No. 22, 4.2–0.8 gpm per square foot for No. 24. Water temperature, 50°F; other conditions as in Fig. 4.

the beds in quantity by the force of the high filtration rates.

An interesting sidelight that was noted during Part 2 of the tests might be mentioned at this point. In the backwashing procedure of Part 2, bacteriological samples were collected at the maximum rise rate of backwash, 25 ipm, about four times the maximum filtration rate, near the end of the washing cycle. Analyses showed standard plate counts as high as 9,160 and a maximum MPN of 240. With practically sterile water in and out of the filters, fairly high chlorine residuals on the filters (about 0.9 ppm during this test), and satisfactory wash water analyses, it may be wondered what chlorine-resistant strain was able to coax an existence from such an inhospitable environment.

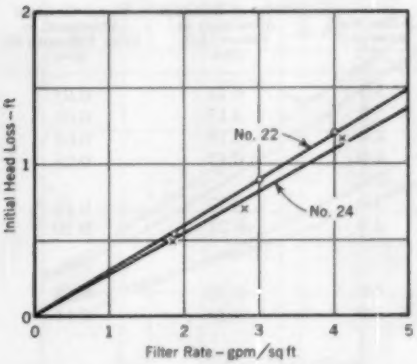

Fig. 7. Initial Head Loss

Rate controller operative; other conditions as in Fig. 4.

Part 2

The principal objective of Part 2 was to determine if the rate controllers on the six new filters functioned properly. In order to gather additional data, however, filters No. 3, 4, 9, and 12 were again tested along with the new filters, under continuous-run and head differential conditions as in Part 1. The rate controllers were set to operate at 8, 6, 4, and 2 mgd, equivalent respectively to 4, 3, 2, and 1 gpm per square foot. The filters were operated only long enough to determine the rate controller action. For this purpose, a normal filter run of 70–80 hr on anthracite and 40–50 hr on sand at about normal rates was generally sufficient.

Bacteriological data were not collected in this test, as data from Part 1 indicated practically sterile water going to the filters and coliform-free water in the filter effluent, rendering data on removal of bacteria nonsignificant. A residual-aluminum test was substituted, to give some indication of floc in the filtered water. Samples were composited from eight points in the filter and from the filter effluent. A chemical analysis was run to determine the residual as aluminum. Bacteriological quality was not disregarded, however, routine analyses during a normal day's operation being used to determine it. The pattern indicated in Part 1 was evident in Part 2, as shown in Table 1. Turbidity samples were collected every 4 hr for the first 48 hr and every 8 hr thereafter until the end of the run. Backwash procedure, bed expansion data, wash water requirements, and so forth were noted as in Part 1.

The results of Part 2 are illustrated graphically in Fig. 7 and 8. For the filtration rates observed on filters No. 22 and 24—up to 4 gpm per square foot—the initial head loss varied approximately as a straight line. Filter No. 24, with the perforated-tile bottom, had a somewhat lower initial head loss than No. 22 for the same filter rate, although the difference was al-

most negligible. When head losses over a continuous run at rates of 3 and 4 gpm per square foot are compared for the two filters, however, the porous plate shows to advantage, with less head loss at both rates (Fig. 8). The rate controllers that were utilized to secure data for Fig. 7 and 8 and Table 2 functioned satisfactorily except at the low settings of 1–1.5 gpm per square foot, where, it is believed, the constant high differential applied across the filters placed the controller beyond its compensating range.

Table 2 compares the performance of filters No. 22 and 24, expressed as million gallons per foot of increase in head loss. In general, the lower rates resulted in poorer performance, and the higher rates in better performance. In this category also, No. 22 showed to advantage.

Table 3 indicates the range of quantities of initial residual aluminum in the filter effluent over the period of the test. Data taken continuously during the run show an average of approximately 0.20 ppm of aluminum in the filter influent and about 0.06 ppm in the effluent, a fairly low order of values. The data indicate about 50–60 per cent removal of aluminum, on the average. It should be noted that the analysis for aluminum accounts for all of the applied aluminum present, whether in solution or in hydroxide form.

TABLE 3

Residual-Aluminum Analysis

Date and Run No.	Water Temp. °F	Filter No.	Initial Rate *gpm/sq ft*	Order of Residual Aluminum to Filters (Al) *ppm*	Initial Residual Aluminum in Filter Effluent (Al) *ppm*
6/3/53	70	3	5.0	0.15	0.03
Part 2		9	5.0	0.15	0.05
Run 1		22	4.0	0.15	0.03
		24	4.0	0.15	0.05
6/3/53	70	22	3.0	0.27	0.22
Part 2		24	3.0	0.27	0.20
Run 2					
6/9/53	70	22	4.0	0.23	0.15
Part 2		24	4.0	0.23	0.17
Run 3					
6/12/53	70	22	3.0	0.17	0.15
Part 2		24	3.0	0.17	0.17
Run 4					
6/16/53	70	22	2.5	0.35	0.28
Part 2		24	2.5	0.35	0.25
Run 5					

Part 3

From Parts 1 and 2, it appeared that filter No. 24 was representative with regard to the performance of the perforated-tile underdrain. As the perfo-

rated asbestos-cement lateral did not appear to be outstandingly better than the other types, it was decided to investigate filters No. 22 and 24 further. Moreover, additional information was wanted on high rates, and, because the highest rates could be obtained from filters No. 3 and 9, they were included in the Part 3 test. Essentially the same conditions prevailed in this part as before, and again maximum rates were employed over continuous runs, but only to the point where the filters dropped below normal rating—about 40 hr on the sand filter (No. 9) and 70 hr on the anthracite filters (No. 3, 22, and 24).

In Part 3, preliminary studies were begun on the depth of floc and mud penetration after rates up to 4.5 gpm per square foot during a continuous run of 70 hr. Core samples of the beds were taken before backwashing, and qualitative determination was made of the amount of floc and mud penetration at increments of about 1½ in. from the surface downward to within about 2 in. of the bottom. As of October 1954, the only determination made was on Filter No. 22. In addition, the porous plates of No. 22 were uncovered, two plates removed, and the plates and filter beneath examined.

Floc and mud were found in easily discernible quantities down to within approximately 2 in. of the underdrain (about a 24-in. penetration), as is shown in Fig. 9. It should be noted that this photograph is not offered as illustrating a quantitative determination, although relative quantities are shown, but only as visible evidence of what was found in one sampling on one filter run starting at a rate of about 4.5 gpm per square foot. Considerably more data are needed before a final analysis can be made. Microscopic examination of the bottom 2 in. of sample showed the presence of floc, but not in significant quantities.

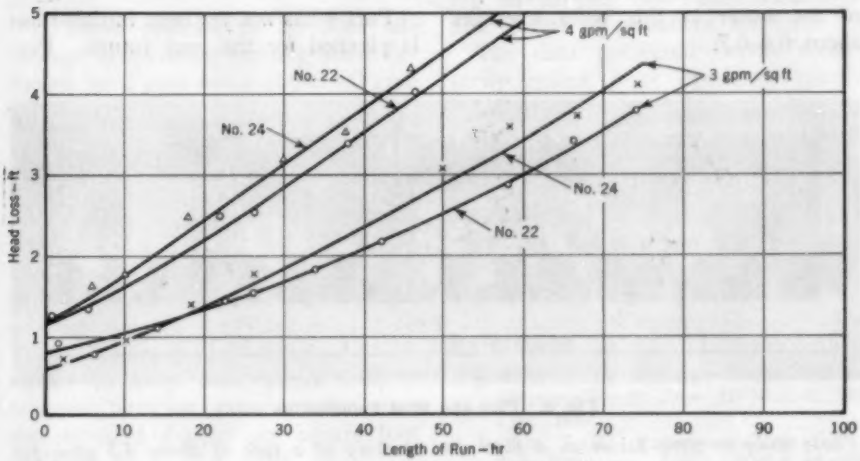

Fig. 8. Comparative Head Losses

Rate controller operative; water temperature, 70°F; other conditions as in Fig. 4.

The examination of the porous plates did not reveal any firm clogging of the pores that normal backwash could not be expected to remove. Loss of head under high rates did not indicate any unusual condition as compared with the tile underdrains. The filter has been in service only 2½ years, however, and further data on backwash will be needed to indicate any trend toward gradual clogging. An examination of the stainless-steel bolts, threads, and washers holding the plates in place revealed no visible corrosion. The pH of the water at this point averages about 6.4–6.7.

crease reached approximately 35 per cent. Based on this relatively short experience, the wash water percentage, which normally would average 2.0–2.3, could be expected to average 2.7–2.8 at high rates, and it might well be anticipated that wash water requirements would increase from 0.3 to 0.8 per cent, if an efficient standard of wash were maintained. Further examination of this phase of high-rate filtration will be carried out in future tests.

Part 4

Part 4 has not yet been initiated but is planned for the near future. Performance tests will be conducted on the six new filters in order to secure comparative data on all of them over an extended period with uniform rates. Further observations on floc penetration, floc passage to filtered water, backwash pressures and head losses, and wash water consumption are also planned.

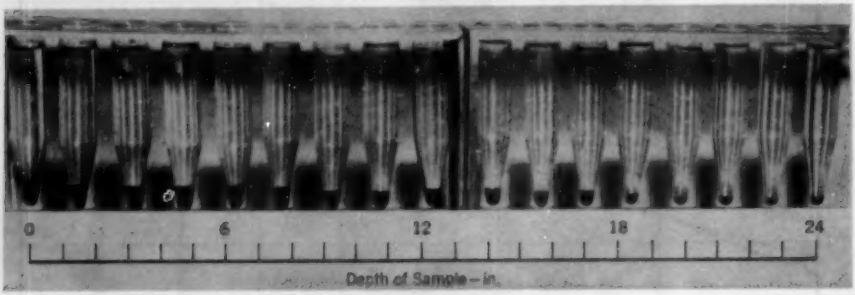

Fig. 9. Floc and Mud Penetration

These samples were taken on a filter run starting at a rate of about 4.5 gpm per square foot.

A description of the results of Parts 1, 2, and 3 with relation to increases in the quantities of wash water due to high filtration rates has been delayed until this point in the paper in order to summarize the data for all three parts of the test. In both Parts 1 and 2, it was found that an average increase of 25 per cent in wash water volume was required to bring the wash water effluent of the filters which had been under high rates to the comparative clarity of a standard wash for filters operated at normal rates. In Part 3, this in-

Conclusions

A study of high-rate filtration is being carried on at the Dalecarlia Filter Plant, Washington, D.C. Results

observed up to October 1954 form the basis for the following conclusions:

1. Water meeting present standards of chemical quality, turbidity, and bacteriological purity can be produced at high rates of filtration—up to 5 gpm per square foot—over a range of temperatures from 50°F to 72°F,* provided that efficient pretreatment (flocculation and sedimentation) is maintained, super- or free residual chlorination is employed, and qualified operating and supervisory personnel are available.

2. There appears to be little advantage in operating existing filters designed for 2 gpm much above 4.0 gpm per square foot. Beyond this point, initial head losses are excessive, even in anthracite media, causing deep penetration of the bed by suspended matter and leading to an early reduction of flow.

3. Head losses at high rates in filter effluent piping and rate controllers are a large part of the total head loss. These appurtenances should be designed to keep head losses low, if nominal filtration rates greater than the standard 2 gpm per square foot are used.

4. In uprating existing filters designed at 2 gpm per square foot, replacement of inefficient or inoperative rate controllers with control equipment operating at less head loss should be investigated.

5. Anthracite with an effective size of 0.76 mm demonstrated more favorable characteristics, at high rates, with regard to all phases of head loss, flow, and length of run than did sand of 0.56-mm size.

6. Wash water use can be expected to increase from about 0.3 to 0.8 per cent under high-rate filtration, depending on varying raw-water conditions and factors of treatment involved.

The data presented herein necessarily reflect plant operating conditions, which, in general, cannot be controlled as closely as in laboratory investigation. It is believed, however, that information based on full-scale operation will be of much value in increasing present plant efficiencies and contributing toward design criteria for use in future planning.

* There is no reason to believe that this statement would not be true over a temperature range from 34° to 85°F, but tests have not been made at these extremes.

References

1. Baylis, J. R. Chicago South District Filtration Plant. *Jour. AWWA*, **41**:599 (Jul. 1949).
2. Baylis, J. R. Experience With High-Rate Filtration. *Jour. AWWA*, **42**:687 (Jul. 1950).
3. Hazen, Richard. Elements of Filter Design. *Jour. AWWA*, **43**:208 (Mar. 1951).
4. Cox, C. R. High-Rate Filtration of Water in Rapid Sand Filters. *Wtr. & Sew. Wks.*, **100**:400 (1953).

Increasing Filter Capacity by Aeration

Pieter C. Lindenbergh

A contribution to the Journal by Pieter C. Lindenbergh, Director of Water Works, Leyden, Netherlands.

THE Leyden Dunewater Co. draws its water from dunes along the coast of the North Sea in the Netherlands (*1*). Geologically speaking, these sand dunes are still very young, a fact which is of some consequence to the quality of the water obtained. It is a little harder than elsewhere and contains rather a lot of organic matter. The iron and manganese in the water are difficult to remove. The rapid sand filter installation experienced difficulties because, in long runs, the filter material (sand and gravel) became extremely sticky. Backwashing with air and water did not prevent clogging, and eventually great cracks occurred in the beds, particularly where the filter material was washed away as a result of the great velocity of the wash water. These problems, which were of the same nature as those described by Baylis (*2*), arose as soon as the rate of filtration exceeded 4 ft per hour (0.5 gpm per square foot).

Increased water consumption made it necessary either to apply a considerably greater rate of filtration or to add new filters. The first method caused serious interruptions of the work at inopportune moments, while the second was very expensive. Moreover, the area from which the water had to be obtained was too small to supply all that would be needed in the near future, and more ground was not available. The company was understandably hesitant to invest large amounts of money in an extension of the rapid sand filter installation, especially as it was not certain that the filters to be added would fit into the plans for a new water supply. Therefore, a solution was sought that would permit a considerable increase in the rate of filtration without causing the above-mentioned difficulties.

The filters were constructed in such a way that it was thought possible at least to double the filtration rate if only the raw water could be pretreated to prevent clogging of the filter material. Pilot tests showed that a rate of at least 15 ft per hour could be employed, provided that complete oxidation of ferrous to ferric iron took place in the water before it was brought on the filters. To obtain this result, aeration of the raw water by means of sprinklers above the filters was tried, but proved to be insufficiently effective, as complete conversion to the ferric state did not take place above the filter bed. Experimental installations were kept in operation for a long time, not without success, but it appeared that application of the methods investigated to the whole plant would be rather expensive.

Aeration Apparatus

The solution finally adopted was to discard the idea of sprinkling the water in the air and, instead, blow the air

into the water in a vertical tube. This is done in such a way that a whirling motion is imparted to the air-water mixture, which is drawn upward owing to the difference in specific gravity between water with air and without air. At the bottom of the tube, a sucking action is created. The apparatus (Fig. 1) is designed so that the water has to pass the air inlet several times. Thus, intense aeration of the water takes place repeatedly.

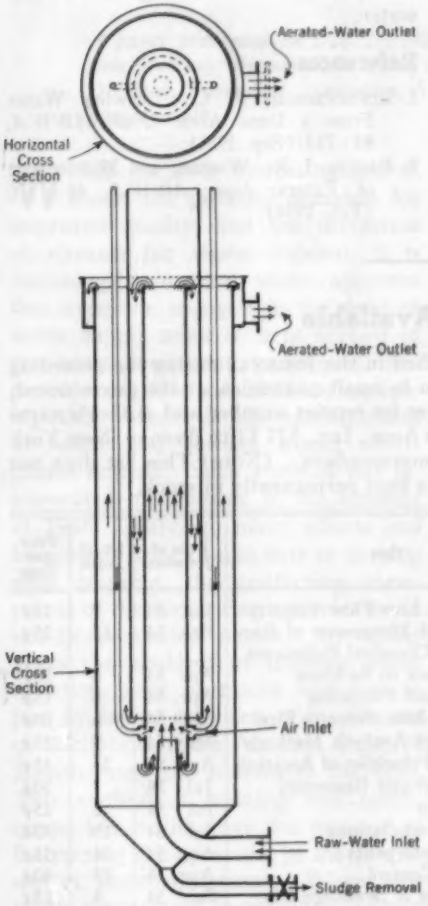

Fig. 1. Aeration Apparatus

This patented apparatus has been used successfully for the pretreatment of high-iron water in the Netherlands.

By this method, not only are the ferrous compounds fully converted in an economical manner, but also all organic matter which can be assimilated is oxidized to the greatest extent possible before the water reaches the filters. All material to be taken from the water is held on top of the filter bed, so that air backwashing might very well be replaced by surface washing. At Leyden, this is not necessary, however, as the present system for washing with air is satisfactory.

The same amount of electric power as needed for sprinkling gives an air pressure just sufficient to overcome the counterpressure (6–7 psi) in the aerator, so that the new method does not increase the cost of aeration. The pretreatment of the raw water with this apparatus was carried out successfully for a year on one filter, which was easily able to sustain a rate of 15 ft per hour. The apparatus has now been adopted for all of the rapid sand filters of the Leyden Dunewater Co., making unnecessary the building of additional filters in the near future and resulting in a saving of about $263,000 in capital expenditure.

It stands to reason that the quantity of air required depends upon the quality of the water to be treated. The more difficult the water is to treat, the more air is needed. For Leyden dune water, a volume of free air equal to about 80 per cent of the volume of water suffices. At one paper mill, however, where even coke filters were ineffective, an equal volume of air and water was required to obtain satisfactory results. There, the water, after

passing through both coke and rapid sand filters, still contained 0.3 ppm of iron, which is too much for the manufacture of paper. By aerating the water in the apparatus described, before rapid sand filtration, the iron content was reduced to 0.08 ppm.

The use of the aeration apparatus, on which a United States patent has been taken out, is not restricted to water works. Paper mills in the Netherlands have found it very useful for the pretreatment of high-iron water. The apparatus gives excellent technical and economical results where other systems have failed. It is likely that it can also be successfully used to clarify all kinds of sewage and waste water.

References

1. LINDENBERGH, P. C. Drawing Water From a Dune Area. *Jour. AWWA*, **43**: 713 (Sep. 1951).
2. BAYLIS, J. R. Washing and Maintenance of Filters. *Jour. AWWA*, **46**: 176 (Feb. 1954).

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Alabama Short-School Program

Arthur N. Beck

A paper presented on Oct. 27, 1954, at the Alabama-Mississippi Section Meeting, Birmingham, Ala., by Arthur N. Beck, Chief Engr. & Director, Bureau of Sanitation, State Dept. of Public Health, Montgomery, Ala.

WITH the ever increasing use of water, the growing demands for improved quality, and the utilization of streams for waste disposal, it is becoming more and more apparent that everyone engaged in the field of water supply must be kept abreast of the latest equipment, techniques, and procedures. One means of accomplishing this purpose is the establishment of water and sewage works short-course schools. Such a school was inaugurated in Alabama in the summer of 1946. Although many efforts had been made prior to that date to develop such training, the conflicting viewpoints of the sponsoring agencies could not be reconciled sooner. In earlier years the problem of training water filtration plant operators was met in part by having engineers of the Bureau of Sanitation of the Alabama Dept. of Health bring the courses to the field. This method of training was inadequate, but it did serve the purpose of instructing the operators in the proper use of plant equipment. When new plants were placed in operation, bureau engineers spent considerable time with inexperienced personnel. They were taught such practical things as which valves to open to filter and to wash and were instructed in the maintenance of equipment, the calibration of feed machines, laboratory tests for coagulation, and chemical laboratory control tests. It is surprising how easily inexperienced men learn the rudiments of plant operation in a relatively short time. It is true that, usually, operation was purely by rote, but, a quality product was generally produced.

Approximately 100 persons attended the first 5-day school in 1946. It was sponsored jointly by the Alabama Polytechnic Institute, the University of Alabama, and the state health department. Since then schools have operated annually, alternating between the two universities, under the sponsorship of the agencies mentioned. The schools have had an average attendance of approximately 110. From the beginning the operators attending showed an intense interest in a certification program. Careful consideration indicated that the best voluntary certification program would be one sponsored by an organization made up principally of water and sewage operators. Consequently, the Alabama water and Sewage Assn. (AWSA) decided to act as sponsor. The objectives of this organization, which is also a cosponsor of the schools, include the advancement of theoretical and practical knowledge in the water and sewage works field, the encouragement of friendly relations and exchange of information among persons concerned with the field, and the development of short-school and licensing programs.

Since the beginning of the certification program in 1950 it has been the policy to give written licensing examinations following the completion of each short-course school. Four grades are offered for water works operators and three for sewage plant operators. The qualifications for each grade are defined in the AWSA bylaws. The bylaws further provide for examining boards, one for each of the two sections (water and sewage). The chief sanitary engineer of the state health department serves as chairman of both boards. At present 92 water works operators and nine sewage plant operators hold certificates. (Certification of sewage works operators was begun in 1953.)

The objectives of a short course should include: [1] development of a deeper appreciation of the responsibilities of the operator's position; and [2] aid in informing the general public of the importance of water supply and sewage works management. In the author's opinion the schools have accomplished these aims to a limited degree. Efforts have been made by the sponsoring agencies and the persons in charge of conducting the courses to give those attending basic academic information, as well as practical operational instruction. Classroom and laboratory work, consisting of both lectures and actual student participation in chemical and bacteriological experiments, has been the practice in the schools. Owing to the complexity of the operation of water filtration and sewage plants, those responsible for developing the courses are prone to overload the programs with courses pertaining to these subjects. The Alabama short courses have, no doubt, been unbalanced at times, but efforts are made to include subjects of interest to all personnel engaged in the field of water works operation, taking into account the fact that only approximately 20 per cent of the water supplies in the state are from surface sources.

Need for Improvement

As has been pointed out, it is felt that the schools have done a wonderful job in accomplishing the purpose for which they are intended, but they are still not reaching the maximum number of people. Although attendance has held up exceptionally well, it seems that many of the students are the same year after year. This is an indication that they are receiving benefits each time they attend, and they ought not to be discouraged from doing so, but the lack of interest on the part of many others, both those in managerial positions and those in plant operation, is rather disappointing. A large number of the water supplies in Alabama, approximately 240, are located in communities of 2,500 people or fewer. It is in this group that interest is lagging, and some means should be found to stimulate their participation. Attendance could be further increased if more managers, especially of water utilities without filtration, could be persuaded to send operating personnel to these schools.

In the past, little or no time was devoted to problems relating strictly to management (with the possible exception of public relations). Absence of courses and lectures in this specialized field may be due largely to management's lack of interest. Although many managers of water supply and sewage works have attended the

schools, no request has been made to include courses of particular concern to this class of personnel. Nevertheless, there is a definite need to expand the school in order to remedy this deficiency. Public relations cannot be stressed too much, particularly at a time when the necessity for water works expansion demands additional capital, which must eventually come from the water users. Every manager of a utility should be well grounded in sound accounting and financing principles, for, without such knowledge, the utility will more than likely be run in a slipshod manner. It is of the utmost importance that all expansion programs be well planned, engineered, and executed. If a utility, whether large or small, is to operate efficiently, the manager or superintendent must be well versed in all phases of business administration. These subjects can be included in the curricula of future schools, and they surely will be, if sufficient interest is shown by water and sewage works managers.

Many other subjects could and should be taught, but existing conditions limit what can be offered. The need for broadening the scope of the school stands out vividly, but at the same time some means must be found to quicken the enthusiasm of water and sewage works men in seeking ways of doing a better job. If such an attitude is brought about, programs can be developed to benefit the personnel of the entire water and sewage works industry rather than only segments of it.

New Edition of Cast-Iron Fitting Standards

The Tentative Standard Specifications for Cast-Iron Pressure Fittings—AWWA C100–52T have been revised. The new (third) edition, which is designated C100–54T, contains the following principal changes:

a. Section 7—Tests of Material—has been revised to conform with the requirements in ASA A21.10 (AWWA C110).

b. The tables of lugs, bends, offsets, reducers, caps, and plugs have been revised to show dimensions of most interest to the trade, such as laying lengths, while minor dimensions of less interest have been eliminated.

c. Comments have been introduced on the possibility of reinforcing or strengthening the larger sizes of tees and crosses, as well as of wye branches.

d. Tables of split sleeves and wall sleeves, not previously included, have also been added.

Water Works Radio in Suburban Philadelphia

George H. Dann

A paper presented on Jun. 25, 1954, at the Pennsylvania Section Meeting, Allentown, Pa., by George H. Dann, Vice-Pres. & Gen. Mgr., Philadelphia Suburban Water Co., Bryn Mawr, Pa.

THE Philadelphia Suburban Water Co. serves approximately 500,000 persons in an area of 300 sq miles. Long transmission lines and pumping stations on the periphery of the territory discharge into a distribution system comprising 1,570 miles of pipe. The company instituted its radio communication system in 1947, at a time when increasing use of water required close synchronization between the sources of supply and the distribution system and when the availability of experienced manpower was somewhat limited.

After a demonstration by the Bell Telephone Co., a radio receiver-transmitter was installed in each of seven cars. In making a call from a car, the receiver was lifted off the hook, sending a signal to the central office in Philadelphia. An operator there would ask what number was desired and would then route the call over land wires or rebroadcast it to another car in the area. For this service, the phone company charged $22 a month per car.

In several years the service had become so popular with the water company and other organizations that there were 45 units on one channel, which, along with the other mobile-radio channels, had reached a saturation point. Consequently, the water company made an investigation to determine what steps it could take to insure that it would have the use of the radio communication system whenever needed. After an analysis of the various proposals submitted to the company, including two by manufacturers of radio equipment, it was decided to accept an offer by the Bell Telephone Co. to provide a complete two-way radio communication service, consisting of a central station, substations at the district offices and pumping stations, and 21 mobile car units. Equipment was to be rented on a monthly basis rather than purchased, to guard against possible losses due to obsolescence. Under the contract, the Bell Telephone Co. furnishes, maintains, and modernizes the equipment.

A 250-w transmitter was located in the Bryn Mawr, Pa., operations building. The antenna, 550 ft above sea level, is attached to a standpipe. Fifty-watt units were installed in the cars, in six substations, and in the home of the distribution engineer. The telephone company charges $85 a month rental for the 250-w base station, $22 for each mobile unit, and $43 for each substation. Since installation, the telephone company has found it necessary to meet many changing conditions, a fact which justifies the decision to rent the equipment instead of buying it. The 24-hr maintenance service pro-

vided by Bell has been very satisfactory. A total of 60 water utility employees are directly concerned with the operation of the radio system.

Uses of Radio

The radio communication system has proved useful for an ever increasing variety of purposes. If a fire breaks out, the water works inspector's car is radioed, and he is requested to go to the location indicated and report on the situation. When the size of the fire warrants it, the inspector checks the residual pressure on the hydrants being used, determines whether any additional supply is required, and radios his findings to the office. If additional supply is needed and the system is not wholly automatic, the superintendent can make adjustments at the pumping stations or at some district valves. This procedure gives the firemen on the job a sense of security, so that they no longer make a habit of calling the water company to demand a greater supply the moment they reach the scene of a large fire.

Because some of the pumps supplying the long transmission lines are of the positive, cross-compound type, line valve closure must be synchronized with the closing down of the pump throttle. Since the radio communication units have been in operation, the practice has been to send a car to the site of each valve involved; the crews then stand by to operate the valve on a signal from the dispatcher or the superintendent at the main office, who is also in contact with the pumping station. A similar procedure, with certain modifications, is employed when the line is ready to return to service.

With the radio communication system, it is possible for the main office to be kept constantly informed of the progress of any repair job, so that inquiring consumers can be told accurately what the probable duration of a shutdown will be. The ability to answer such questions precisely is of great public relations value.

Because of the extensive area served, the routes of inspectors and metermen are often far removed from the central office. This situation makes radio particularly useful in handling emergency calls. The central office knows just what man is available in a certain territory and can notify him of the call within a few minutes of receipt. Furthermore, when an order is transmitted, it is picked up by every receiver on the network, so that a roving inspector in the neighborhood of the emergency can often handle it.

On one occasion a woman customer in a suburban area phoned rather frantically to report that a broken water pipe was flooding her basement. Not 2 min after she hung up, her doorbell rang. On answering, she found a water company inspector there. Of course, such an incident is not usual, but it does illustrate what radio can accomplish.

Water system radio communications would undoubtedly be of great assistance in peacetime catastrophes, as well as war disasters. The local power company normally supplies the base stations, but the water utility maintains gasoline-driven generators as standby units. With the flip of a switch and the starting of a motor, the stationary transmitters could operate on emergency power, while the mobile units would run on the car battery, as they do ordinarily. Thus, even if the local telephone and power systems were put out of operation, the water works

could still operate efficiently. During a terrific rainstorm on Nov. 25, 1952, many power lines were disrupted, and the telephone system was so flooded with calls that it was impossible to transmit orders to the pumping stations and distribution units. By utilizing an emergency circuit, however, the water company was able to maintain contact and continue its operations. This occurrence emphasized the need for standby power.

Conclusion

This paper has described the benefits of radio communication experienced by the Philadelphia Suburban Water Co. Whether radio would prove equally beneficial for other utilities depends, of course, on the specific conditions under which they operate. As with other equipment and procedures, the value of radio must be balanced against its cost. Some of the benefits—such as savings in labor time and car mileage—can be evaluated on a dollar basis. Others—like enhanced public relations, minimizing of damage from main breaks, and assurance of continued operation in time of disaster—are difficult to assess in terms of money.

In considering the use of radio, a water works manager should analyze the needs of his system, study the possible savings radio might effect, and obtain concrete proposals with regard to installation, operation, and maintenance of radio facilities. It should then be feasible to determine whether radio service would be practical and economical.

Chloride Contamination of Ground Water in Ohio

A. A. Ulrich

A paper presented on Sep. 24, 1954, at the Ohio Section Meeting, Dayton, Ohio, by A. A. Ulrich, Vice-Pres., Ohio Water Service Co., Massillon, Ohio.

WHEN streams are excessively contaminated by sewage and industrial wastes, the situation can often be remedied in a relatively short time by removing the source of pollution. If surface water containing highly mineralized wastes seeps through the ground into underlying fresh-water aquifers, however, the results may be felt for a decade or more, and the affected ground water may never regain its original quality.

Massillon and other Ohio cities in the Tuscarawas and Muskingum valleys are fortunate in having access to large bodies of underground water. While industrial and municipal supplies elsewhere were being threatened by shortages, these cities enjoyed an abundance of water for all purposes. But now they are faced with a most serious problem—contamination by chlorides.

A survey conducted by the Ohio River Valley Water Sanitation Commission found that brine wastes are a major pollutant in the Muskingum River and its tributaries. Chlorides, once added to water, are not reduced by natural purification, nor can they be economically removed by other means. Water heavily contaminated with chlorides is lost for many uses. Because of the high salinity of the Muskingum and Tuscarawas rivers, they have become unsuitable as a source of domestic and industrial water supply. The high noncarbonate hardness caused by this salinity is costly to remove, and the high chloride content causes saline taste.

Infiltration of the river waters into public wells located along the streams has caused considerable trouble by degrading water quality. The lowering of ground water levels during severe drought periods, as in 1953 and 1954, has made the situation more critical. Because of chloride contamination of existing wells adjacent to the Tuscarawas River, Coshocton, Ohio, has been forced to develop a new source of supply on the Walhonding River, at a cost of approximately $500,000. Similar difficulties with high chloride and hardness concentrations in the raw water have been experienced at Marietta, Ohio, whose wells are near the Muskingum River. Conditions at Massillon, however, are by far the most serious.

Difficulties at Massillon

The public water supply for Massillon is owned and operated by the Ohio Water Service Co., a private firm. The primary source of supply has always been wells drilled into gravel water-bearing strata. This water has been of a very high quality, although fairly hard. The company constructed a lime–soda ash softening

plant in 1931 to reduce the hardness of the water. In 1936 the company installed an intake on Newman Creek, a small, spring-fed stream that flows by the plant and discharges into the Tuscarawas River, several hundred yards east of the water plant. This surface supply was intended for auxiliary use in the event of pump failure or repairs to the single 36-in. deep well, then the primary source, which produced 2 mgd. In order to keep pace with the growth of the city and to meet increasing demands, the company, in June 1951, drilled a new well, known as Well No. 2, which produced 3 mgd. The old well (No. 1, drilled in 1922) and the new one are 200 ft apart and are located approximately 200 yd west of the Tuscarawas River.

For many years the normal hardness of the ground supply at Massillon averaged 380 ppm; 140 ppm was noncarbonate hardness, and the chloride content was 8 ppm, making it economically feasible to soften the water for domestic and industrial usage. Starting in August 1952, the water from both wells gradually increased in hardness and chloride content. By November 1953 the hardness of Well No. 1 had reached a maximum of 1,686 ppm, with 1,469 ppm noncarbonate hardness and a chloride content of 1,700 ppm. The total hardness of Well No. 2 was 660 ppm, of which 444 ppm was noncarbonate, and the chloride content was 670 ppm. By this time the chemical cost per million gallons of water treated had increased from $18 to $55. Samples of Tuscarawas River water taken at a point opposite the wells showed chlorides as high as 10,350 ppm and a total hardness of 3,800 ppm (3,663 ppm noncarbonate). As a result, Well No. 1 has had to be abandoned and Well No. 2 is now the auxiliary supply, with the Newman Creek surface supply the primary source. Well water is used only as makeup, the chloride content being reduced by mixing with surface water.

This high-chloride condition has appeared in many of the private well supplies of Massillon industries. Chloride contents range from 200 ppm at the Massillon Steel Casting Co. and 500 ppm in several Republic Steel Corp. wells to 2,000 ppm in the well at the Massillon Paper Co. In the author's opinion, this very critical situation will continue at Massillon until the indiscriminate discharge of wastes into the Tuscarawas River and its tributaries is stopped.

Conclusion

Unless immediate action is taken to remedy stream pollution by chlorides, the Ohio Water Service Co. may be forced to abandon the present well supply at Massillon. The extent of chloride contamination of the ground water basin may have made it useless to drill new wells near the existing plant. Obtaining suitable supplies elsewhere, whether from wells or impounded surface waters, will require heavy expenditures, resulting in increased water rates. Thus, the industrial future for Massillon may be in jeopardy, and an abundant ground water supply may be lost forever, not only to Massillon, but to all other communities in the Tuscarawas River Valley.

Discussion

Art Robinson

Director of Public Relations, State Water Pollution Control Board, Columbus, Ohio.

New evidence brought to the attention of the Ohio Water Pollution Control Board indicates that the chloride contamination of ground water in the area under discussion may be resulting from causes other than infiltration from brine-contaminated surface streams. This evidence relates to the magnesium content of the contaminated well water, as compared to that of brine mined and used by industry in the Barberton, Ohio, area. Although not conclusive, the evidence suggests the possibility of a breakthrough from the underlying bittern layer into the fresh-water horizon of the well fields, which could result from hard pumping of the underground supply. Whatever the true explanation may turn out to be, it is obvious that regulatory agencies should be cautious in forming conclusions on the first set of facts presented.

The basic problem of water pollution in this area, however, exists without regard to underground infiltration by chlorides. As defined in the Ohio Water Pollution Control Law, pollution means "the placing of any noxious or deleterious substances in any waters of the state which [are] harmful or inimical . . . to the use of such waters for domestic water supply" or for certain other proper and legitimate uses. Undoubtedly the amount of chlorides discharged into the Tuscarawas River by the operations of an existing chemical company is sufficient to make large sections of that "water of the state" unsatisfactory for use as a domestic supply. If the Tuscarawas River (and, downstream from it, the Muskingum River) were a suitable source for domestic water, the problem of infiltration by chlorides into wells would be of less significance, no matter what the source of the chlorides might be, because the wells themselves would not be a necessity.

Two other sections of the Ohio law have an important bearing on this case. In the section which prohibits acts of pollution, there are certain exemptions, one of which applies to "any industrial wastes or acid mine drainage until the [State Water Pollution Control Board], after a hearing, determines that practical means for the removal of the polluting properties of such wastes or drainage are known." There has been no such hearing to date with regard to the brine discharge of the chemical company involved. Another section of the law calls on the pollution control board, in making its decisions, to "hear and give consideration to evidence relating to conditions calculated to result from compliance with such orders, and their relation to benefits to the people of the state."

It should be pointed out that the new pollution control law was passed in 1951 and did not take full effect until Sep. 27, 1952. Every state agency like the pollution control board faces the problem of establishing a new type of regulation on an existing framework of economic development with a minimum disturbance of that framework. The case under discussion is a perfect illustration of the problem. On one

side are a number of communities, with a population of 145,000, whose water supply is involved. On the other side is an industry half a century old, with a reported investment of $60,000,000 employing more than 2,000 persons, whose families and whose home community also are concerned.

The company claims to have invested already more than $1,000,000 in previous efforts to reduce waste discharge. It has employed a highly reputable engineering firm to seek methods for further reduction. Company officials have stated publicly that the firm is ready to spend another $1,000,000 as soon as somebody can tell it how to spend the money and get the results desired. The company has voluntarily placed itself under regulation by the State Water Pollution Control Board, without demanding a hearing on the feasibility of treating its wastes. No discharge permit has yet been granted to this industry by the pollution control board. A hearing on the granting of such a permit has been continued, pending further engineering studies and investigation. The final answer in this case is not available at the moment.

Perhaps most important of all is the fact that the solution to this problem is being approached in an atmosphere of reasonableness by all of those involved. It has been the feeling of members of the Ohio Water Pollution Control Board that such an approach is best in the long run. Lest anyone make the mistake of thinking that such an attitude is one of leniency, however, it should be said that the members of the board are also convinced that the pollution of streams or other bodies of water by brine or any other deleterious substances must and will be ended shortly. Even if present laws should prove inadequate, that opinion would not be changed. Thoroughly alerted now to the dangers of pollution, the public will see to it that laws are placed on the books to give the desired protection.

Distribution System Pressure Problems

Panel Discussion

A panel discussion presented on Sep. 16, 1954, at the Michigan Section Meeting, Muskegon, Mich. The paper on leak and waste surveys by Cyrus R. Bird, Vice-Pres., The Pitometer Associates, Inc., Chicago, has been omitted because several articles on the subject have recently been published in the Journal (including W. D. Hudson, "Flow Tests on Distribution Systems," page 144, Feb. 1954; and H. E. Beckwith, "Planning Distribution System Improvements at Newport News," page 329, Apr. 1954).

Value of Hydrant Flow Tests—*R. C. Loughead*

A paper presented by R. C. Loughead, Chief Engr., Michigan Inspection Bureau, Detroit.

A WATER works engineer, when designing a new water system and having all the necessary data, can, by formula, estimate fairly accurately the quantity of water that should be available at different locations. After the system has been operating for a number of years, however, increased friction loss in the mains and changes in consumption requirements will materially affect the original computations, so that hydrant flow tests become necessary in order to provide properly for meeting the changed conditions. If system requirements are known, flow tests may indicate deficiencies, and, in addition, the fire department will be in a position to operate more efficiently at a large fire when aware of any water system weaknesses that may exist. Many water superintendents know little about what their system will produce, especially for fire protection. Hydrant flow tests are the only method of obtaining this information. There seems to be no reason why such tests cannot be made at the time the hydrants are flushed, with practically no additional expense. The tests will also indicate closed or partially closed gate valves and, under certain conditions, may even disclose leaks.

The flow of water from an orifice, in gallons per minute, is equal to $29.7\ d^2\ \sqrt{P}$, in which d is the orifice diameter, in inches, and P is the pressure, in pounds per square inch, as measured by a pitot tube. This is a small brass tube, about $\frac{1}{16}$-in. ID, which is fastened to a blade and to which a pressure gage is attached so that the small waterway and the gage are connected. With the pitot opening held in the center of the stream, directly opposite to the direction of flow and about half the diameter of the hydrant outlet away from the outlet, and with the blade cutting the stream, a pressure reading is obtained on the gage. Tables showing orifice flows for various diameters and pressures can be used in place of the formula.

For measuring the flow from a fire hydrant, the table employed is usually based on a coefficient of 0.90, which, on the average, compensates for the loss in pressure in the hydrant, especially at the throat, due to turbulence. For example, the table will show that a pitot reading of 9 psi on a hydrant with a 2½-in. outlet corresponds to a flow of 500 gpm. This figure does not mean a great deal, however, unless the static pressure at no flow and the residual pressure at full flow are known. The difference between the static and the residual pressure represents the friction loss in the distribution system from the source of supply to the point of discharge.

Test Procedures

The simplest way of conducting flow tests, particularly applicable in the smaller towns, where the expected flow is rather small, is by the "single-hydrant method." Although it is not entirely accurate, the results do indicate any weakness that may exist in the distribution system. As automobile motor-driven pumpers are in almost universal use by fire departments, all flows are changed to a 20-psi residual basis, so as to be comparable. This sort of test is not made if the flow is expected to exceed 1,000 gpm; thus, it would ordinarily not be used when the hydrant is fed from a main 8 in. or larger.

For the single-hydrant method, the only equipment required is a spare 2½-in. hydrant cap, drilled and tapped with a ¾-in. pipe thread, to which an ordinary pressure gage is attached. One of the 2½-in. caps of the hydrant to be tested is removed and replaced by the test cap and gage. With all outlets closed, the hydrant valve is opened at least to a point where the drain is closed, and the static pressure is read on the gage. (For this illustration, assume the static reading to be 45 psi.) The hydrant valve is then closed, and, when the pressure is relieved and becomes zero, the other 2½-in. cap is removed and the inside diameter of the butt measured to the nearest $\frac{1}{16}$ in. (Assume that a 2½-in. ID is found.) Next the hydrant valve is fully opened (if it is not opened fully, an error will result). The gage pressure will drop to practically the same reading as would be obtained if a pitot tube were placed in the stream. (Assume that the pressure reading is now 29 psi.)

The flow tables show that a flow through a 2½-in. hydrant outlet with a pitot reading of 29 psi is 910 gpm—that is, the hydrant in question has delivered 910 gpm at a residual pressure of 29 psi, a 16-psi drop in pressure due to friction (45-psi static minus 29-psi residual). Applying the knowledge that the flow varies approximately as the square root of the pressure drop, the following equation can be set up to find the flow at 20-psi residual pressure:

$$\frac{x}{910} = \frac{\sqrt{45-20}}{\sqrt{45-29}} = \frac{\sqrt{25}}{\sqrt{16}} = \frac{5}{4}$$

$$x = 1{,}140 \text{ gpm}$$

Consequently, this hydrant could have delivered 1,140 gpm at 20-psi pressure, if there had been an outlet large enough (a little more than $3\frac{1}{16}$ in.) to permit it.

For greater accuracy, the 0.54 power of the pressure drops should be compared, as this is the actual figure appearing in the Hazen-Williams for-

mula, but it does not vary materially from the square root, which is the 0.50 power. Applying the 0.54 power instead of the square root in the preceding illustration, the quantity discharged at 20-psi residual pressure is found to be 1,158 instead of 1,140 gpm, an error of about 2 per cent. Hydraulics is not an exact science, however, and errors up to 10 per cent may be expected.

A few Michigan cities record the results of such flow tests on individual cards for each hydrant. Using these data, hydrants can be colored to show the approximate flow that may be expected at 20-psi residual pressure—red when less than 500 gpm is available, orange for 500–1,000 gpm, and green for more than 1,000 gpm. Other classifications or colors may work to better advantage. One city, after obtaining these data, not only placed them on cards, but drew up a contour map showing the three flow classes in color, so that, when a 10-in. feeder main was extended into a manufacturing area, the resultant change in the map was a graphic illustration of the effect of strengthening the distribution system in that part of the city.

A method frequently used to determine the adequacy of the supply for an automatic sprinkler system is to measure the flow by a pitot tube at a hydrant in the vicinity of the building in question, taking the static and residual pressures at an adjacent hydrant. With this method, the friction loss between the two hydrants must be considered, and the calculations may be somewhat involved if the main is circulating.

In the high-value or factory districts of the larger cities, where from 1,000 to 5,000 gpm or more is available, it is necessary to open two or more hydrants (sometimes as many as six) in order to obtain sufficient drop in pressure. Assuming that, after studying the distribution system, it is decided that a reasonable drop, 10–50 per cent, requires the 4½-in. pumper outlets to be opened on four hydrants, the following procedure is employed: The engineer in charge chooses the hydrant where the tests are to be conducted. Four other men, each provided with a pitot tube connected to a pressure gage, then take a flow reading at four adjacent hydrants surrounding the static hydrant. Each man conducting a flow test removes the hydrant cap and measures the outlet diameter to the nearest $\frac{1}{16}$ in. At a signal from the engineer in charge, who has recorded the static pressure, the four hydrants are opened simultaneously and, in response to another signal, the four pitot and the residual readings are taken. To take an example from an actual test, a 60-psi static reading dropped to 34 psi while the total discharge from four hydrants was 5,870 gpm. From these figures, it was determined that 7,400 gpm would be available at 20-psi residual pressure. In this particular area, only 5,000 gpm was required, thus showing a strong distribution system at that point.

Fire Flow Requirements

In order to be acceptable for fire protection, distribution mains should be capable of delivering at least one hose stream (250 gpm) at the weakest point in the system. When it becomes necessary to measure such small flows, a fire department nozzle with a 1-in., or even smaller, tip is attached to the 2½-in. hydrant butt. In this way, flows

as low as 50 gpm can be measured with considerable accuracy.

Knowing how to conduct a fire flow test is of only nominal value unless the quantities required under different circumstances are also known. To estimate the required fire flow, the National Board of Fire Underwriters uses a formula which makes an allowance for probable loss due to broken connections incident to a large fire. This formula is:

$$G = 1{,}020\sqrt{P}\,(1 - 0.01\sqrt{P})$$

in which G is flow, in gallons per minute, and P is population, in thousands. The formula is based on the assumption that the fire flow requirements vary with the population; in order to have no deficiency by NBFU standards (*1*), the required amount should be available even on maximum-demand days. On a few occasions, the requirements may be increased or decreased, depending upon the character of the property to be protected.

The fire flow requirements for cities and towns of various populations are shown in Table 1. It will be noted that, in small towns, the required duration of fire flow is 4 hr, a period which increases to 10 hr for towns of 6,000 population or more. If a town of 10,000 population has a minimum elevated storage of 600,000 gal, a 10-hr fire flow duration (600 min) applies (see Table 1); 600,000 ÷ 600 = 1,000 gpm, which is the amount credited for the elevated tank. Such storage is much more reliable than a pump of equal capacity and has the added advantage, if the mains are of sufficient size, of permitting the discharge of greater amounts for shorter periods.

In general, the minimum NBFU fire flow requirement, even for residential areas, is 1,000 gpm, but, in the smaller towns, this amount is seldom available. As stated before, there must be at least 250 gpm available if a system is to be recognized as furnishing any fire protection. In cities with up to 10,000 population, there should be a minimum of at least 500 gpm available in all residential areas; in larger cities, the required amount may reach 3,000 gpm, depending upon the size and height of the buildings and the extent of the built-up area. The fire flow requirement for industrial plants, schools, churches, minor mercantile establishments, and so forth is more of a problem, and the answer is usually arrived at through experience, although a rather complicated formula can be applied. In practice, the Michigan Inspection Bureau tries to compare the property under consideration with the business sections of a certain city having comparable hazards, taking into account the relationship between population and required flows as given in Table 1.

TABLE 1

Fire Flow Requirements *

Population	Fire Flow *gpm*	Duration *hr*
1,000	1,000	4
2,000	1,500	6
3,000	1,750	7
5,000	2,250	9
10,000	3,000	10
17,000	4,000	10
40,000	6,000	10
100,000	9,000	10

* Based on NBFU standards (*1*).

Water supply requirements for automatic sprinklers vary from 500 gpm up, depending upon the size, height, construction, occupancy, exposure, and

other characteristics of the property in question. The amount can be determined only when all these conditions are known. The required flow should be available at a residual pressure of at least 15 psi at the highest line of sprinklers. This means that the pressure required at street level would be equal to the height of the building (in feet, divided by 2.31) plus 15 psi.

The bureau has come to the conclusion that the water system in cities of 5,000 population or less is not generally designed to furnish an adequate supply to automatic sprinklers. During the past several years a number of manufacturers have erected plants on the outskirts of small towns where there is seldom enough water available for fire protection. In one village, the authorities promised a manufacturer an adequate water supply if he located within the village limits. After the factory had been erected and placed in operation, plans for automatic sprinklers were submitted to the bureau. Records indicated that water was supplied to this property through 1,200 ft of 4-in. dead-end main, and a flow test showed less than 250 gpm available. In order to supply the required amount (1,000 gpm) at sufficient pressure, it would have been necessary to lay a 12-in. main from the village gravity tank to the property, a distance of about a mile. As the cost of this improvement would have amounted to more than the original cost of the entire water system, needless to say, the sprinklers were not installed. The supply for fire protection is still less than one hose stream. In such instances, the owner can always install his own water supply.

Conclusion

On a number of occasions when flow tests showed less water than might be expected, the cause was finally determined to be a closed or partly closed valve. In one such case, involving a city of 60,000 population, it was found that a 16-in. valve in one of the two main feeder lines supplying the business section was entirely closed.

Incidents of this type emphasize the fact that hydrant flow tests are of the utmost importance. This means of knowing his system should not be overlooked by the progressive water superintendent.

Reference

1. *Standard Schedule for Grading Cities and Towns of the United States.* Natl. Board of Fire Underwriters, New York (1942); *Jour. AWWA,* **34**: *following p.* 1584 (Oct. 1942).

Pressure Records—*Alfred E. Hansen*

A paper presented by Alfred E. Hansen, Cons. Civ. Engr., Muskegon, Mich.

The average distribution system represents approximately two-thirds of the capital expenditure of the entire water utility. Being covered by about 5 ft of earth, it is not visible to the eye and, consequently, does not receive the same attention in the matter of inspection and record keeping that is provided for the remaining third of the system, the supply and treatment facilities.

As a practicing engineer, the author has been employed by various communities to study their water distribution systems and make recommendations to correct their "lack of pressure." In other words, the distribution system was functioning inefficiently, and the degree of this inefficiency would usually be in direct proportion to the consumers' complaints. Generally there would be excellent records of filtration plant and pumping station operation, but very meager data on the pressure at various points on the distribution system. A pressure-recording gage is usually found at the pumping station; one may also be found at the city hall; and, occasionally, some of the fire stations may have one. Rarely are such gages placed at the critical or key points of the distribution system; instead, convenience is often the deciding factor. As a result, the pressure records available are of little value to the engineer in making an analysis of the system's deficiencies.

In the study of any distribution system, it must be borne in mind that the function of the system is to transmit water at a maximum hourly rate in a certain quantity, to various points, under a desirable pressure. When the system meets these qualifications satisfactorily, it can be considered to be functioning efficiently. The purposes for which water is transmitted through the system can be broken down into three classes: fire protection, industrial and commercial use, and domestic consumption.

Fire flow requirements can be obtained from NBFU ratings and applied to the various zoned areas of the municipality in proportion to the zoned value. The industrial and commercial demand can be found by making a survey of all the existing establishments of this type. From a study of their various operations and processes, the peak demand loads for this group can be determined.

The peak domestic demand occurs during the summer, when the sprinkling load is heaviest. This is the load that taxes the distribution system to the utmost. In order to determine its effect on the system, it is necessary to establish temporary pressure gage stations at the key points of the system. These gages are all tied in to a particular elevation datum. From pressure recordings made during the heavy-demand periods in the summer, the low-pressure points can be determined and a solution to such problems arrived at. Although this is the method generally used, it leaves much to be desired, as it gives one only a glimpse of the picture that is sought, and makes necessary certain assumptions that are largely guesswork.

A more desirable way to approach this problem, for the average municipality, would be to provide a series of permanent pressure-recording stations at key points in the distribution system —on feeder branches, on the secondary lines from feeder mains to residential or industrial and commercial areas, and also on the lines that serve large industrial plants. It would be desirable for the gages to be placed in manholes, thereby eliminating the possibility of tampering. The gages themselves need not necessarily be installed permanently, but it would be very desirable to have a 24-hr chart each day during June, July, and August. Then the gages could be removed and stored until the following year. At least one pressure recorder, however, should be kept in operation the year round.

After the charts from the various pressure-recording stations have been collected, a single graph should be made of all the charts for each station. This graph would indicate the times of low pressure or deficient operation at the gaging point and should be compared with the charts for previous years. A collection of such pressure data over a 5-year period would provide the engineer with a fund of invaluable information, enabling him to solve thoroughly and efficiently the deficiencies apparent in the system. Moreover, heavy drawdowns from industrial plants would be recorded on these graphs, and this undesirable situation could be corrected. In effect, a series of permanent pressure-gaging stations located at the important points on a distribution system would serve as observation posts to indicate the trend of the efficiency and operation of the system.

Practical Value of Records

To cite an example of the value of pressure records not only for correcting deficiencies in the system, but also for revealing unusual conditions, the problems encountered by a small municipality will be described. The town in question, which has a population of approximately 3,000, is strictly a residential area. The city charter prohibits any commercial or industrial concern employing more than eight people. The residences probably range in value from $10,000 to $150,000. The city is about 4 miles long and half a mile wide, with an elevated tank approximately in the center of the 4-mile length.

During the summer complaints of low pressure began to be received from the high-value residential area, which is located about 1¼ miles west of the elevated tank. The tank had a working level of 120 ft, giving a pressure of 52 psi at its base. An 8-in. feeder main, with 6-in. laterals, served the area from which the complaints were coming.

The first step taken was to run pressure gagings on a dry, hot day, when everyone was sprinkling, from the elevated tank to the center of the area, at intervals of approximately 1,000 ft. At the tank, 52 psi was recorded; as readings were taken along the route, they continued to decrease until a point at the center of the low-pressure area was reached where a recording of 8 psi was noted. There certainly was justification for complaints about low pressure, and there undoubtedly was something wrong, as the gage readings showed. The next step was to determine the amount of water used, to see whether the enormous pressure loss was due to the demand load of the area.

A year with a hot, dry summer was selected for study, and the summer quarterly consumption of each consumer was noted; these data were plotted on a map as total consumption per block and average daily consumption per consumer per block. Then the city was divided into seven districts, and the total consumption for each district was determined, as well as the average daily consumption per consumer. The results were surprising, to say the least. The high-value districts had 3½ times the daily consumption of the moderate-value districts, with nearly 50 per cent of the maximum hourly demand load concentrated in two of the high-value sections. Although the maximum hourly demand normally ranges from

three to five times the average hourly figure, in this instance the maximum was fifteen times the average. This situation was corrected by means of a 12-in. feeder main loop.

Had permanent pressure stations been established, this distribution deficiency could have been detected and remedied much sooner, and a serious fire hazard would not have existed in the area for years. Largely unforeseen increases in the use of water due to the installation of garbage disposal units, automatic washing machines, automatic dishwashers, and air-conditioning units are taxing to the utmost many distribution systems designed and built 15–20 years ago. Permanent gaging stations would provide a set of pressure records indicating the weak points of such systems and permitting early correction of deficiencies.

Booster Stations—*A. T. Kunze*

A paper presented by A. T. Kunze, San. Engr., Wayne County Board of County Road Comrs., Detroit.

The growth of the Detroit metropolitan area since the close of World War II, and the parallel increase in water usage, which continues at an ever rising rate, are currently pointing up the deficiencies in water supply facilities in much of the region. Actual water shortages in many suburban districts during the hot-weather months are forcing responsible officials to seek a solution of the problem. Since 1944, the Wayne County Board of County Road Commissioners has been operating a semimetropolitan authority to provide water supply and sewage treatment facilities for a considerable portion of the county. The authority's water customers are located in the extreme fringe areas, well beyond the Detroit city limits. As a result, it has become necessary to operate four booster pumping stations with elevated storage and two with ground level storage.

Booster stations may be required in a water distribution system for one or both of two reasons: [1] to provide higher pressures to an area at an elevation too high for the main pumping station to serve it adequately; [2] to provide relief for an area, remote from the pumping station, which experiences low pressures due to friction losses in the supply mains, the distribution system, or both. Either condition may be aggravated by an inadequate supply of water during peak-demand hours. It is obviously useless to attempt to correct low-pressure conditions by boosting when these conditions are caused primarily by the lack of an adequate supply, unless the supply is to be augmented in some manner, such as by the use of storage reservoirs at the booster station. It is also evident that neither booster stations nor storage at the stations will produce more water. These facilities can be effective only if the main source of supply is of sufficient capacity to produce the total demand for a 24-hr period. Only then can enough water be stored during the offpeak hours as a reserve to be drawn on to satisfy peak demands.

The essentials of booster station design closely resemble those for any other water pumping station. The fundamental considerations are:

1. Future population and water consumption
2. Average, maximum, and minimum rates of demand
3. Pressure conditions throughout the area and at the pumping station, under various loads
4. Volume and type of storage
5. Number, sizes, and characteristics of pumping units
6. Type of motors and starters
7. Selection of voltage for electric power
8. Automatic controls
9. Protection against surge
10. Miscellaneous details.

The following discussion of these fundamental considerations is based largely on experience with one particular district, which is served by a booster station (Fig. 1) with both ground and elevated storage. This cannot be called a typical installation, for the reason that no two areas present exactly the same problems. In order to keep this discussion within reasonable limits, it is necessary to omit a great many details that might logically be included.

Description of District

The area involved was undergoing rapid residential development and industrial expansion. The approximate center of population was located about 12 miles from the main pumping station, the extreme customer 22 miles, and the intensive industrial development 16.5 miles. The 1950 population served with water was 47,000 and the 1960 and 1970 populations were estimated at 85,000 and 142,000, respectively. Differences in ground elevation throughout the district were negligible, and there was no elevated storage. The existing 36-in. supply main had become inadequate to furnish peak-demand requirements even for the 1950 population, and the increasing demands on the system clearly indicated the necessity for a booster station with storage.

The location of the booster pumping station was determined chiefly by the availability of suitable sites upstream from all branch lines. The site selected placed the station 8 miles from the main pumping station and about 8.5 miles upstream from the heavy industrial development. It was assumed that, after not more than 10 years, an additional supply line would be extended into the area, thereby reducing the load on the proposed booster station. Consequently, present pumping facilities were planned to meet the area requirements for that period. Thereafter the facilities would serve a smaller area adequately for several more years, as it continued to grow in population. Eventually the pumps might be replaced with larger units, if the demand continued to increase.

TABLE 2

Water Consumption Figures

Year	Avg Day *mgd*	Max. Day		Max. Hour	
		mgd	Per Cent of Avg	*mgd*	Per Cent of Avg
1951*	4.5	7.6	170	13.5	300
1953†	7.5	15.0	200	22.5	300
1953*	6.4	12.2	190	19.0	297
1962†	13.0	23.0	175	32.5	250

* Actual rates recorded.
† Design rates.

Consumption and Pressure

From past records of population growth and water use, projected esti-

mates of water consumption were made. The average usage for the years 1945–50 was about 90 gpcd, but, owing to the anticapated general increase in water use and also to the fact that the district was becoming more industrialized, the consumption figure for design purposes was arbitrarily increased to 135 gpcd. Actual and design quantities are shown in Table 2.

It will be noted that the maximum-day and maximum-hour rates for 1962 were set at 175 and 250 per cent of the average day, respectively, regardless of the higher maximum rates for the year 1951. This reduction was predicated on the assumption that increasing industrial expansion would tend to level off the peaks.

Fig. 1. District Booster Station

This station and storage reservoir are located about 8 miles from the main pumping station.

A study of the feeder mains and distribution system, using conventional methods, indicated that, in order to maintain a minimum of 30-psi pressure in any part of the district during peak-demand hours over the 10-year design period, it would be necessary to increase the pressure at the station during such hours to 70 psi. A minimum of 40-psi pressure had to be maintained in the supply line at a control point about a mile upstream from the booster station, and it was assumed that there would be a minimum of 35 psi available at the pump suction.

Volume and Type of Storage

Figure 2 indicates hourly variations of water usage in the area for the peak day during 1951. It also shows an estimated hourly demand curve for the peak day during 1962, assuming that the additional supply line will not yet have been constructed. These curves follow the typical pattern, with a morning peak, a heavy early-evening peak, and a rapid drop in demand after 8 PM.

It was estimated that, in 1962, during the hours of 9 AM–10 PM, the system would deliver water to the booster station at a safe maximum rate of 15 mgd. The balance of the demand during these hours would be satisfied by drawing from storage. This estimate was predicated on the assumption that pressure conditions in the supply system would be improved prior to 1962.

Elevated storage was considered desirable as a means of leveling the pumping rate and providing a reliable method of pump control. From the top curve in Fig. 2, it was assumed that the usage in excess of 26 mgd would be supplied from elevated storage and that the usage between 15 and 26 mgd would have to be supplied from ground storage, the latter representing a total of 6 mil gal for the 13-hr period. It was decided to construct elevated storage of 1-mil gal capacity and ground storage of 6-mil gal capacity, representing a total storage of about 30 per cent of the maximum-day demand.

Pumping Units

There is always the question of how far an engineer should go in estab-

lishing specific requirements which must be met to qualify a product for acceptance. Each pump manufacturer has a standard line of units that may be adapted to meet various requirements by changing impeller diameter or design or by operation at different speeds. In addition to the usual specifications for centrifugal pumps—indicating the type of pump, materials, bearings, couplings, and the like—the Wayne County board habitually specifies capacity at a specified net head, motor horsepower, maximum speed, maximum and minimum shutoff heads, suction diameter, and discharge diameter. The board also requires that the following information be submitted, all of which is considered in analyzing the bids: characteristic curves for individual pumps; characteristic curves for all possible parallel operating conditions, which must indicate overlapping head curves within specified head ranges; diameter of present impeller; maximum and minimum impeller diameters; and guaranteed pump efficiency at design point.

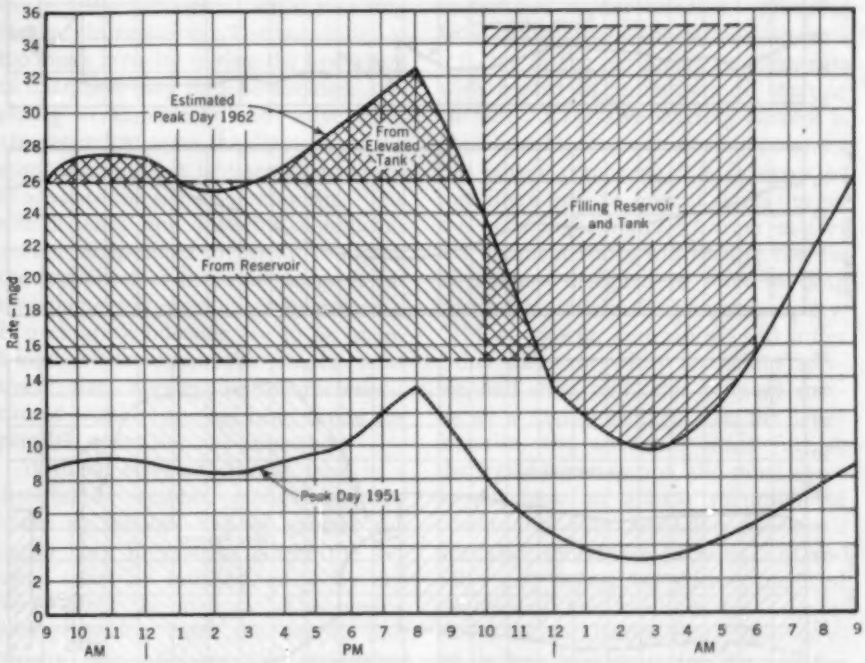

Fig 2. Peak-Day Consumption

A safe maximum rate of 15 mgd was estimated for system delivery to the booster station, the balance of the peak-day demands to be supplied from storage.

It would take too much space to elaborate on all these items but, in

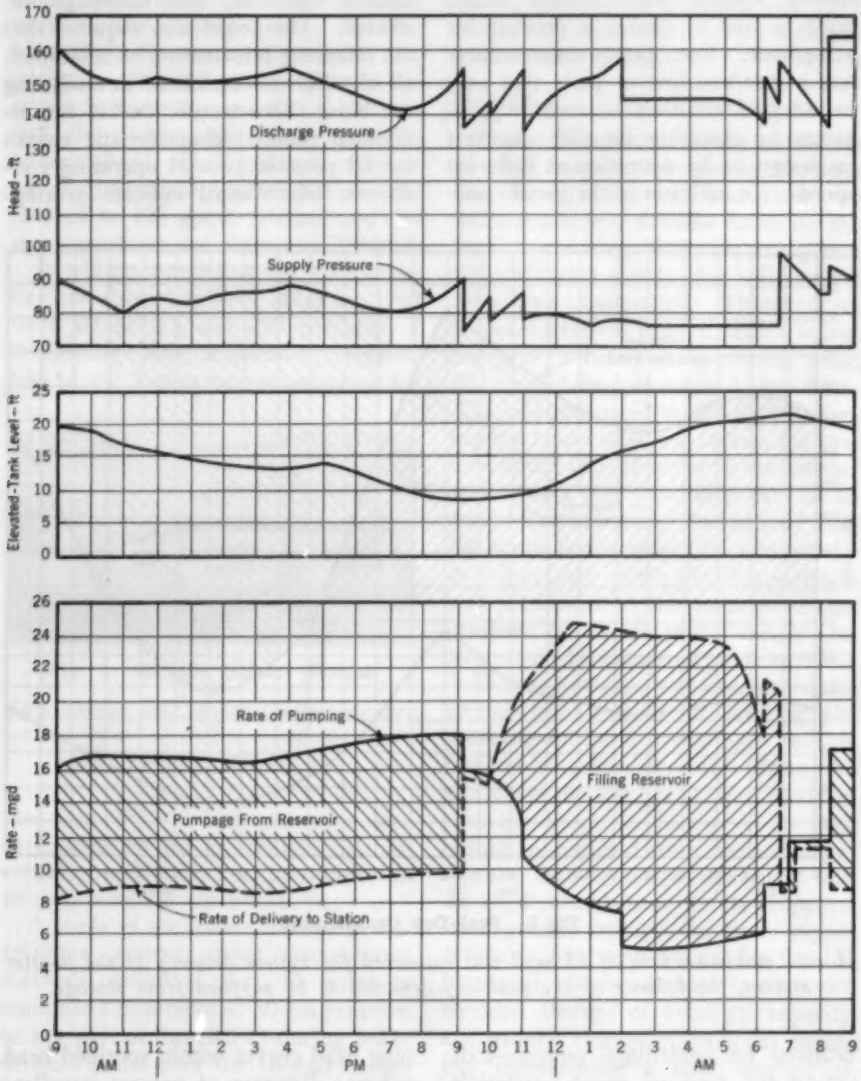

Fig. 3. Booster Station Operation, Typical Peak Day

Preceding 12-month average, 6.70 mgd = 100 per cent; peak day, 13.41 mgd = 200 per cent; maximum-hour pumpage rate, 18.00 mgd = 269 per cent; maximum-hour usage rate, 19.20 mgd = 286 per cent.

the author's opinion, many of them are important for booster pumps. High pump efficiencies are, of course, desirable; in small installations, however, other considerations may be more important. Motors should be sized to make certain that they will not be overloaded under any possible operating condition and to permit future changes in impeller diameter, with resulting changes in capacity. The possibility of too much capacity during the first years of operation may then be avoided. As piping arrangements and valve sizes are dependent upon the diameter of the pump openings, it is essential to know in advance the size of pump units. The size of pump and diameter of impeller should be specified to permit changing the capacities of the units to meet future changes in operating requirements. If pressure conditions are to be maintained within reasonable limits, relatively flat, overlapping characteristic curves within specified head limits for parallel operation are important.

With an elevated storage tank in a distribution system, pumps may be fewer in number and of greater capacity than in systems where the demand must be satisfied solely by delivery from the station. The pumps taking suction from the supply line usually may all have like capacities, and there should be at least one pump in reserve at all times. Where peak demands are to be met by supplementing the supply from storage reservoirs, an additional pump or pumps must be installed. The capacity of these pumps must be determined by deducting from the peak pumping demand the rate that might logically be expected to be available from the system during the high-demand period. The characteristics of the reservoir pump should be such that its shutoff head approximates the shutoff heads of the system pumps corrected to include the residual head available on the suction side of the latter.

Motors, Starters, and Voltage

Usually requirements of the local power company dictate the type of motor and starter selected. Distance from transformer substations often is a factor in the particular requirements with regard to limitations on starting current. Excessive starting current is objectionable from the standpoint of the power company if it is expected that there may be several starts during the early night hours. Larger motors and frequent starts will require the use of starters designed to limit starting current to satisfy the power company.

Most power companies will offer either 220-v or 440-v secondary service, and some will offer primary service at a higher voltage. In the latter instance, the customer must furnish the transformer station and must agree to purchase an annual minimum of power. If only secondary power is available, the choice between 220 and 440 v may depend on whether qualified electricians are available for maintenance, on the theory that 220-v service is less hazardous for the average pumping station operator. Of course, 440-v service makes for a somewhat cheaper installation.

Usually the rate for primary service is so attractive that the additional investment in transformers and switchgear is well worth while, if the annual power consumption will qualify for this type of service. In Wayne County, it was necessary to guarantee a minimum consumption of 500,000 kwhr per year to qualify for primary service.

Automatic Controls

It is always desirable to make a small pumping station as nearly automatic as possible, principally to save on operating cost. Assuming a 40-hr week and allowing for vacation, holiday, and sick-leave time, the services of five operators would be required to provide full-time coverage for a pumping station, at an annual cost that could easily exceed $20,000. Wayne County has elected, where possible, to provide only part-time attendants and assume the calculated risk of losing a motor or pump occasionally. In 10 years of operation no piece of equipment has been lost. In each of the boosted systems, however, remote recorders are maintained, with alarms which indicate high and low water levels in the elevated tanks. These recorders are located in installations where there is constant attendance by switchboard operators or watchmen who are instructed to notify the proper persons in the event of trouble.

Experience indicates that the only reliable method for controlling pumps automatically is to cut them in or out according to the height of water in an elevated storage tank. Controlling pumps by pressures at the station or from remote points in the system is always subject to too many variables created by usage, pipe friction, and other factors. When the water level in an elevated tank is falling, the system usage is generally increasing, indicating the need for more pumping capacity, and, conversely, a rising level indicates the need for fewer pumps in service. The settings for the sequence of pump starts and stops may be at intervals of several feet, thereby avoiding too frequent starts and stops. As a second or third pump comes into service, the tank will absorb any surplus of water over immediate system demand, thereby avoiding intermittent pressure buildup to a dangerous point.

Leased telephone wires between the tank, the pumping station, and watch points are economical and reliable. There are a number of systems on the market which will record the elevation of the water in the tank and provide adjustable controls for operating several pumps. It is a good policy to install these units with transfer plugs or some other means of changing the sequence of pump operations without disturbing the settings on the controls.

The Wayne County authority has never attempted to operate a booster station entirely automatically during the season of heavy demand, when it is necessary to use water from the storage reservoirs regularly during the peak hours. For the stations where storage is available, this means that, for an average of about 100 days per year, 24-hr attendance is necessary to accomplish refilling of the reservoirs at night and to coordinate pumping from storage during the day with the pumps which take their supply direct from the system.

TABLE 3

Cost of Booster Facilities, 1952

Facility	Capacity	Unit Cost
Pumping station	20 mgd*	$9,500/mgd
Ground storage	6 mil gal	5.75¢/gal
Elevated storage	1 mil gal	21¢/gal

* Present capacity of pumps; may be increased by addition of new unit or by changing impellers in existing pumps.

Protection Against Surge

If the supply line and the distribution system are to be protected against

surge, which, if not controlled, may easily build up pressures sufficient to rupture the mains, considerable attention must be given to the type of pump check valve and the method of starting and stopping the pumps. In the author's opinion, compression chambers and relief valves are not reliable means of guarding against surge and should not be depended upon. Wayne County has standardized on rotary plug type check valves, hydraulic-cylinder operated and solenoid actuated. With this arrangement, all starts are against a closed valve. After the start, a pressure switch activates the solenoid which opens the port to the underside of the hydraulic cylinder and slowly opens the valve. When stopping, the valve is almost completely closed before the power circuit is broken. A second solenoid operates a quick-opening port to the valve, which functions only if there is a power failure.

Check-valved cross connections between supply and discharge at the booster stations permit flow through the stations to satisfy small demands in the system without pumping and will provide some service during a power outage.

Miscellaneous Details

Among the other details that enter into the design of a booster pumping station are: adequate pipe sizes for present and future capacities, with reasonable head losses; proper valving to permit servicing of each unit; provision for forced ventilation to rid the station of excessive heat; and proper recording instruments to indicate rate of flow, daily usage, supply and discharge pressures, and elevated-tank and storage reservoir levels.

Operating Experience

Figure 3 shows the results of booster station operation for a typical peak day. It will be noted that, during the critical hours from 8 AM to 10 PM, the maximum rate of delivery to the station did not exceed 10 mgd, while satisfying the system demand of 13.41 mil gal over the 24-hr period and the peak-hour demand of 19.20 mgd. During the same hours the minimum supply pressure was 34 psi and the station discharge pressure was held within a range of 61–69 psi.

The rate of refilling of the reservoir between 10 PM and 7 AM, plus the delivery rate to the system at the same time, imposed a maximum rate of 25 mgd on the supply, without unduly affecting the supply pressure. It will also be noted that the 24-hr demand for this day was exactly 200 per cent of the previous 12-month average day and that the peak-hour rate was 286 per cent, very closely approximating the original estimates.

The cost of the booster facilities for the district discussed, including construction, engineering, and administrative charges, but not including land cost, is shown in Table 3.

Preview of the Tenth Edition of *Standard Methods*

Louise C. Carty

A revision of a paper presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by Louise C. Carty, Chemist, Dept. of Water & Power, Los Angeles.

A JOINT editorial board, composed of representatives of the American Public Health Assn., the American Water Works Assn., and the Federation of Sewage and Industrial Wastes Assns., has directed the preparation of the tenth edition of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes,* which will be available soon. The members of the board are, respectively: Mac Harvey McCrady, Harry A. Faber (chairman), and William D. Hatfield.

The most important change from the ninth edition (published in 1946) is in the manner of presentation. Wherever possible, each method is accompanied by a brief but thorough discussion of the principle underlying it, the significance of the result, factors influencing the choice between alternate methods, special precautions concerning sampling and storage, possible interferences and their elimination, stability of reagents, expected sensitivity and accuracy, and applicable concentration ranges; complete, up-to-date bibliographies are also included.

The organization of the book is based on the concept of convenient and logical presentation for ease in use. All cross references are by page number. No methods appear in the appendix; they are designated either "standard" or "tentative" and appear alphabetically in their proper place in the text.

The book is divided into six parts: [1] Physical and Chemical Examination of Water; [2] Physical and Chemical Examination of Sewage, Treatment Plant Effluents, and Polluted Waters; [3] Physical and Chemical Examination of Industrial Wastes; [4] Physical and Chemical Examination of Sludges and Bottom Sediment; [5] Routine Bacteriological Examination of Water; and [6] Biological Examination of Water, Sewage Sludge, or Bottom Materials.

Many new methods have been added, old methods improved, and some deleted entirely. The book contains tests for some constituents for which there was no test when the ninth edition was published. The changes, in general, show advantages in increased speed of analysis; increased accuracy; simplification of technique, material, or equipment required; or elimination of troublesome interferences. Many charts, tables, and line drawings have been added.

A section on instrumental methods discusses the use of the automatic titrator, the flame photometer, and the spectrograph. Details of their use are not given, but the analyst is referred to manufacturers' manuals and to the bibliographies.

Part I

The major changes introduced in Part I, water analysis, are:

Alkalinity. The related determinations of acidity, alkalinity, carbon dioxide, carbonate, bicarbonate, hydroxide, and pH are unified. Nomographs are included for the determination of the different forms of alkalinity and carbon dioxide. They are based on the most recent information about ionization of carbonic acid and effects of ionic strength and temperature. The Cooper mixed indicator is offered as an alternate for methyl orange indicator, as it permits the selection of the different equivalence points that correspond to the different concentrations of alkalinity encountered. Titrimeters, pH meters, and automatic titrators are allowed.

Fluoride. A spectrophotometric method is given. Interferences are discussed quantitatively. A method is given for the removal of chlorine.

Calcium and hardness. The Schwarzenbach method, using disodium ethylenediaminetetraacetate solution, is given for the volumetric determination of calcium and total hardness. Definitions of the various forms of hardness are rewritten for greater clarity. The palmitate and soda reagent methods are omitted.

Iron. The thiocyanate and the gravimetric methods are omitted; the phennanthroline method is revised. A new tentative method less subject to interfering ions, which uses tripyridyl as the colorimetric reagent, is presented.

Phosphate. The gravimetric ammonium molybdate method for the determination of orthophosphate is replaced by a volumetric method; the two colorimetric methods which are suitable for different concentration ranges are retained. A method for converting polyphosphate to orthophosphate with subsequent colorimetric determination as total phosphate is given. The manganous chloride method for pyrophosphate is eliminated.

Sodium and potassium. The flame photometric method is discussed but not described in detail. The analyst is referred to the bibliography. The perchlorate method for potassium is omitted, and a semimicro method for potassium is added, based on the oxidation of potassium cobaltinitrite with ceric sulfate and titration of the excess ceric salt.

New procedures. These include: the Gutzeit mercuric bromide method for arsenic; a colorimetric method, using carmine, for boron; the "cuprethol" method for copper; the amperometric titration method for free and combined chlorine (including a procedure for differentiating monochloramine and dichloramine); Palin's method for differential titration for free available chlorine, monochloramine, and dichloramine, and an estimation of nitrogen trichloride; two new oxidation methods for total chromium; greatly modified periodate and persulfate oxidation methods for manganese; a method for iodide which makes use of the catalytic effect of iodide on the oxidation of arsenite by cerate; the brilliant yellow method for magnesium; calculations for saturation index, stability index, and percentage sodium; a turbidimetric method for sulfate; a dithizone method for zinc; and a mercuric nitrate titration method for chloride.

Deleted methods. These include: the gravimetric method for aluminum; the evolution method for carbon dioxide; the hydrogen sulfide precipitation method for lead; the titan yellow method for magnesium; the benzidine method for sulfate; the nephelometric method for zinc; and the perchloric acid method for total chromium.

The introduction to Part I has been expanded and brought up to date. There are discussions of the general aspects of water analysis, such as representative

sampling, changes during storage, acceptable types of containers, interferences, theory and practice of photoelectric methods (including comparison with visual methods and discussion of the use of permanent color standards, solutions, or colored glass), and instrumental methods. Three different methods for checking the accuracy of a water analysis are given. A discussion of statistics, including precision and accuracy, significant figures, and methods of expressing probable error, also appears.

"Milligrams per liter" (mg/l) is recommended as a more correct method for expressing concentration, although the old terminology of "parts per million" (ppm) is still recognized.

Part II

Part II, sewage analysis, contains the following new features:

Precision and accuracy. There is a discussion of precision and accuracy. The statement of precision and accuracy that is given with most of the methods in Part III is defined. Precision is expressed in terms of the standard deviation to be expected under routine conditions and represents the work of at least three laboratories running ten tests on a sewage or effluent sample on ten different days. Accuracy, when it can be determined, is the actual percentage recovery of the true amount present.

Acidity and alkalinity. An electrometric method is added.

Chlorine residual and chlorine requirement. The same methods as presented in Part I are used with modifications to make them applicable to sewage and industrial wastes. A new concept of "chlorine requirement" replaces "chlorine demand" and is defined as "that amount of chlorine required to meet a certain specification, such as 90 per cent coli destruction, 100 per cent CN destruction or 70 per cent color removal, etc."

Phenol. Two methods are given. The old "nonstandard" method using 2,6-dibromoquinone-chlorimide has been modified to increase its sensitivity. Another colorimetric method, using aminoantipyrine, has been added, and the bromate volumetric method has been omitted.

Grease. A new method is given.

Part III

Part III, for the analysis of industrial wastes, has been changed as follows:

Color. A "standard" spectrophotometric method for the determination of color and a "simplified" photometric method using three filters are presented.

Oxygen consumed. A dichromate oxidation method replaces the permanganate method for oxygen consumed. The value is now designated as "COD" or "chemical oxygen demand."

Dissolved oxygen. A tentative polarographic method is proposed for use where heavy concentrations of wastes make the Winkler procedure (which is retained) inapplicable.

Biochemical oxygen demand. The manometric methods of Sierp and Warburg are presented for use with industrial wastes at low dilutions when the standard dilution method is undesirable.

Metal ions. Tentative methods for the colorimetric determination of metal ions (Cu, Cd, Cr, Pb, Ni, Zn, Fe, and Mn) and total cyanide in industrial wastes from metal-plating and metal-treating plants, in the presence of large quantities of one another, are included.

Part IV

Part IV, sludge and bottom sediment analysis, contains two new methods, for grease in sludges and for volatile acids in sludges.

Part V

Part V, which contains the tests for the bacteriological examination of water, has undergone a number of revisions:

The major change has been the adoption of tryptone glucose extract agar without skim milk as the required medium for the standard plate count. This change, as well as the changes in requirements for glassware and equipment, was made so that the methods will conform more closely to those for milk given in *Standard Methods for the Examination of Dairy Products*, in order to eliminate the need for two different kinds of media.

The coliform test now permits the use of lauryl sulfate tryptose broth as an alternative medium in the presumptive test. Gas formation in both lactose broth and lauryl sulfate must be confirmed by inoculation into brilliant green bile broth or lauryl sulfate tryptose. Other types of inhibitory media for confirmation of positive presumptive tests are eliminated.

The use of the "most probable number" index (MPN) has been continued and is now the only recommended method for indicating coliform-organism densities. The use of the "indicated number" has been eliminated. A table gives the MPN indexes when a series of three replicate portions of each of three or more volumes of sample is employed. The US Public Health Service standards for drinking water are included in full for information. As the subject requires thorough treatment because of its complexity and cannot be adequately covered in a work of this sort, no attempt has been made to discuss the interpretation of results or to give limiting standards of water quality.

Excerpts from the British standard methods have been included as tentative methods for information only and are not established as alternatives for the accepted standard procedure using lactose broth. As in the ninth edition, the discussion of the rationale of the coliform test is included; and, in the tenth edition, the directions for carrying out the technical procedures made official in the British methods are also given.

A new section providing tentative methods for the detection and identification of the higher bacterial forms which are the basis of slime deposits in many water works structures is presented. Plans for future editions are based on the hope that further studies will be made and that standard techniques can be given.

Part VI

Part VI, containing the biologic or microscopic methods, has been completely revised. It now includes a discussion of methods of sampling, as well as procedures for identification of organisms. It has also been improved by the addition of line drawings and photographs of microorganisms as an aid to the identification of species under microscopic examination. Both the areal standard unit and the volume standard unit have been incorporated as standards for expressing the results of biologic or microscopic examinations.

Acknowledgment

Much of the information about the parts other than Part I, on water, was taken from a review article (*1*) edited by the three members of the joint editorial board. A debt of gratitude is due to these men and the organizations they represent, as well as to all of the other individuals who have generously given of their time, skill, and knowledge to make the improvements possible. More particularly, in regard to the section on water analysis, the members of the AWWA Standard Methods Commit-

tee and nonmember contributors, listed below, are deserving of a vote of thanks from the future users of the tenth and later editions of *Standard Methods.*

Reference

1. "Standard Methods . . ." (Proposed Changes for the Tenth Edition). *Am. J. Pub. Health,* 43:643 (1953).

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Experience With Activated-Silica Treatment

L. L. Klinger

A paper presented on Sep. 28, 1954, at the Wisconsin Section Meeting, Green Bay, Wis., by L. L. Klinger, Project Engr., Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

DURING the last decade the use of activated silica as a coagulant aid in water treatment has become quite prominent. It is often employed for improving efficiency, economy, or capacity, or some combination of these, not only in water works but in sewage and industrial-waste treatment as well. In the latter field, the author has encountered many interesting applications through his connection with the paper industry.

Chemical and other considerations involved in the coagulation of colored and turbid surface waters have been discussed by numerous investigators. Colored matter in water is chiefly due to gallates, humates, and other organic matter, usually negatively charged and colloidal. Turbid matter in water usually consists of silt, clays, and other fine soils eroded by a moving stream, some of the suspended matter being due to the motion of the stream itself, but a greater part being the result of colloidal reaction. Generally, the colloidal charges are negative. Algae are another annoying source of turbidity.

The coagulation of colored waters is usually accomplished with an acidic chemical such as alum, the required dosage of coagulant being generally proportional to the color in the raw water. If the natural alkalinity present is insufficient to react with the coagulant, artificial alkalinity is added in the form of soda ash or lime. Excessive alkalinity can be reduced with an acid reagent like sulfuric acid. In the coagulation of turbid colored waters, the chemical demand likewise depends on the amount of turbidity present. Turbidity may or may not be beneficial, depending upon the colloidal nature of the particles producing it. Investigators have often wondered why coagulation is more difficult at some times than at others. A buffering or changing colloidal condition may be the explanation in some instances.

Silica Activation

In the course of a series of tests to find an unknown substance which aided the coagulation of Lake Michigan water, Baylis (*1*) used various chemical reagents of salts commonly present in water and found that silica in a certain form assisted in the process. The silica solution first prepared was made from an old sample of sodium silicate that had been exposed to air and was thus partially carbonated. When fresh solutions failed to work, a restudy was made. Fresh silicate was heavily carbonated to produce the desired results, and refined tests indicated the necessity of an activant for producing a colloidal sol. Baylis was the first of many investigators to patent a silica sol.

Activated-silica hydrosol is prepared by employing a reactant with a suitable grade of sodium silicate, such as one having 1 part Na_2O (sodium oxide) to 3.2 parts SiO_2 (silicon dioxide). A typical analysis is: Na_2O, 8.9 per cent; SiO_2, 28.7 per cent; and H_2O, 62.4 per cent. The stoichiometric balance involved is best demonstrated by typical reactions (Table 1). A less usual type is that developed by Graf and Schworm (*2*) for the very turbid waters of the Mississippi. In this process, a 1 per cent alum solution is mixed with a 1 per cent silicate solution in a 4 : 1 ratio and fed continuously as a coagulant.

Reactions 1, 3, and 4 are typical neutralization reactions in which the alkalinity of the sodium oxide in the silicate is reduced. Reaction 1 must be carefully controlled because of the strongly ionized sulfuric acid used, and the neutralization is usually extended only to 85 per cent at a 1.5 per cent silica aging concentration. Reactions 2, 5, and 6, involving the use of alkaline reactants, result in the formation of slightly ionized, heavily hydrated, gelatinous salts (*3*). It should be noted that, in Reaction 2, water is absorbed, whereas, in the other reactions, extra water is produced. In Reaction 3, it is believed that the resulting silica sol is tied up with alumina and an unknown quantity of water.

Activation or colloidal "micelle" growth (indicated by "$^-SiO_2^-$" in Table 1) occurs through the release of silica from the sodium silicate. The degree of activation, which can be adjusted for different applications, is controlled by the starting dilution of the silicate and by the reaction temperature. The colloidal condition of the $^-SiO_2^-$ is stabilized by secondary dilution with water. After a certain aging time at a specific starting dilution in batch treatments, the colloidal solution is further diluted by approximately 50 per cent more water. Then the relatively stable sol can be put into process by a proportioning pump, a batch being large enough to last economically for a convenient time until

TABLE 1

Typical Silica Activation Reactions

No.	Designation	Reaction
1.	Baylis sol	$H_2SO_4 + Na_2O \cdot 3.2SiO_2 \cdot xH_2O \rightarrow Na_2SO_4 + 3.2\ ^-SiO_2^- + (x+1)H_2O$
2.	N-Sol A	$(NH_4)_2SO_4 + Na_2O \cdot 3.2SiO_2 \cdot xH_2O \rightarrow Na_2SO_4 + 2NH_4OH + 3.2\ ^-SiO_2^- + (x-1)H_2O$
3.	N-Sol B*	$Al_2(SO_4)_3 + 3(Na_2O \cdot 3.2SiO_2 \cdot xH_2O) \rightarrow Al_2O_3 \cdot 3(3.2\ ^-SiO_2^-) \cdot yH_2O + 3Na_2SO_4$
4.	N-Sol C*	$Cl_2 + H_2O \rightarrow HOCl + HCl$ $HOCl + HCl + Na_2O \cdot 3.2SiO_2 \cdot xH_2O \rightarrow NaOCl + NaCl + 3.2\ ^-SiO_2^- + (x+1)H_2O$
5.	N-Sol D*	$2NaHCO_3 + Na_2O \cdot 3.2SiO_2 \cdot xH_2O \rightarrow 2Na_2CO_3 + 3.2\ ^-SiO_2^- + (x+1)H_2O$
6.	Carb sol	$CO_2 + H_2O \rightarrow H_2CO_3$ $H_2CO_3 + Na_2O \cdot 3.2SiO_2 \cdot xH_2O \rightarrow Na_2CO_3 + 3.2\ ^-SiO_2^- + (x+1)H_2O$

* Marketed by Philadelphia Quartz Co., Philadelphia; No. 2 and No. 4, H. R. Hay; No. 3, C. L. Baker and C. H. Dedrick.

the next one is made. In continuous treatment, for reasons of convenience and economical size of equipment, aging is accelerated and then halted abruptly by considerable dilution to stabilize the sol, which is used immediately.

Jar Test Trials

In order to determine whether or not activated silica may be of benefit to the individual plant, it is recommended that some preliminary jar tests be run. The current chemical dosages can be used as a base line for investigating the effect of the silica. If multiple-jar testing equipment is available, the base-line dosage can be employed, say, in Jars No. 4, 5, and 6 in a six-place stirrer; in Jars No. 1, 2, and 3, the base-line dosage can be reduced by 10–15 per cent. The standard chemical reagents are measured into the various samples, and the stirrer is started. Dosages of standard silica are added after the floc has begun to form. For control purposes, the first sample in each series of tests should not receive silica treatment. In the others, increments of activated silica can be added until an optimum quantity is found. Except in rare instances of extremely high turbidity, addition of the silica after the floc has started to form seems to be preferable.

Most water work operators dealing with treatment plants have facilities to prepare their own standard chemical reagents or can obtain them locally. It is well known that these reagents should be prepared from the same materials used in the treatment, if at all possible. For jar testing of silica sols, it has been found most suitable either to get an activated-silica sample from someone who is using it or to prepare it in a fairly large batch. Instructions concerning the preparation of laboratory batches have been issued by a large supplier of sodium silicates, who has led in the development of silica sols. The author has employed these with varying degrees of success. In the last few years mixing kits have been furnished by the same supplier, but the author has not had an opportunity to try them. The best success in experimental work has been achieved with a 50-gal batch in a clean barrel. Such an arrangement seems to produce sols most nearly comparable to those in actual large-scale batch operations.

For such a batch, 14.6 lb of 41°Bé (Beaumé) sodium silicate is carefully weighed and diluted in 26 gal of water. If accurate weighing is not possible, an exact volumetric measurement of 5 qt of silicate gives the same quantity. For a simple preparation of an activated sol (N-Sol D), 3.5 lb of sodium bicarbonate (baking soda) is added to 6 gal of water in a large, clean crock or pail and stirred until it is all dissolved. As soon as this takes place, the solution is added slowly to the diluted silicate with rapid stirring (a wooden stirrer can be used). The batch, now having an approximate total volume of 33 gal, is ready to age at a silica concentration of 1.5 per cent. After aging for 1¼–1½ hr, the volume is brought to 50 gal by diluting with water and mixing. The resulting sol, with a concentration of 1 per cent silica, is now aged and stabilized. One milliliter of this solution is equivalent to 10 ppm silica in a liter jar test sample. It is usually unnecessary, with the colored or turbid water encountered in Wisconsin, to use more than 2–7 ppm as a coagulant aid.

Plant Trials

The ultimate refinements in the control of silica dosage can be made only in plant practice. The jar test is a useful guide, but a simple plant trial will show more positively what the silica actually will do and how it might alter plant operation either beneficially or detrimentally. In plant practice, it is usually unnecessary to employ as much silica as the optimum dosage found in the jar tests. Unless the use of more silica would obviate the necessity for expanding plant facilities, it is better to balance the added silica cost against savings in other chemicals. Improved efficiency may justify increased cost, but overoptimism should be guarded against.

To feed 1 ppm of activated silica requires 29 lb of 41°Bé sodium silicate for each million gallons of water produced daily (100 gal of dilute solution containing 1 per cent silica). If delivered in 8,000–9,000-gal tank cars in central Wisconsin, the cost of 29 lb of silicate is $0.39. In barrels in small lots, the cost is approximately $0.87 for the same quantity. Adding the cost of the various activating agents, the price of treating 1 mgd will probably range from $0.55 to $1.03. If a chlorine-activated sol is used, however, the chlorine is available for chlorination, so that its cost cannot be assessed against the sol.

Advantages of Various Sols

Table 2 lists the various common sols applied by the author in his work. Their advantages and disadvantages are described below:

Baylis sol. This is a very active and effective sol. Because strong sulfuric acid, diluted to approximately 10 per cent, is used as the reactant, special acid-handling precautions must be taken by the operators. The sol can be made continuously with special equipment.

N-Sol A. This is also a very active and effective sol. The reactant salt, ammonium sulfate, is easy to weigh and dilute and is not harmful to handle. The use of this sol is indicated where ammonia is necessary for chloramination. If considerable high-pressure boiler water treatment is involved, however, there is the disadvantage that excessive ammonia is hard on copper fittings, especially when much recycling of condensate is practiced. The sol can be prepared continuously.

N-Sol B. This sol has proved fairly effective under the treatment conditions encountered by the author. Extreme care must be exercised in diluting the alum to approximately 25 per cent of the total of the aging volume, the remainder being made in the diluted silicate. The diluted alum must be added to the diluted silicate with considerable agitation or a precipitate will result. The fact that alum is usually available makes additional chemical inventory unnecessary.

Bisulfate. This is an effective sol similar to the Baylis type. The chemical is easy to handle. Its use is particularly indicated when the sodium bisulfate byproduct market becomes attractive.

N-Sol D. This effective and easily prepared sol has the special property of keeping for long periods. Its use is indicated in smaller plants where it is desirable to make fairly large batches at intervals.

N-Sol C. This is an effective sol more adapted to continuous than to batch preparation. As previously mentioned, the chlorine activant may be used for disinfection.

Carb sol. This is a relatively effective sol on surface waters. It was

tested quite extensively by the author in 1945, with continuous preparation, using modern orifice gas-feeding equipment (*4*). The sol can be used profitably in softening plants where carbon dioxide is produced for recarbonation, if it is possible to meter the carbon dioxide under constant pressure. It is practical for use in certain industrial territories where a very cheap source of carbon dioxide bottled gas is available. A considerable amount of work has been done by Henry (*5, 6*), Black (*3*), and Andrews (*7*) in Florida on the carbon dioxide sol.

TABLE 2

Data on Sol Types

Sol Type	Activating Agent	Reaction *per cent*	Amount of Agent per Pound of Silicate *lb*	SiO_2 Dilution		Aging Time *hr*	Approx. Alkalinity ($CaCO_3$)		Approx. Gel Time *hr*
				Aging *per cent*	Finished *per cent*		Aging *ppm*	Finished *ppm*	
Baylis	H_2SO_4 (66°Bé)	85	0.129	1.5	1.0	1–2	1,100	735	3–5
N-Sol A	$(NH_4)_2SO_4$	100	0.190	1.75	1.3	1–2	8,850	6,600	24
N-Sol B	alum	75	0.206	1.5	1.0	1–2	1,850	1,250	12
Bisulfate	$NaHSO_4$	79*	0.311	1.5	1.0	1–2	1,600	1,060	5
N-Sol D	$NaHCO_3$	90	0.217	1.5	1.0	1–2	13,700	9,200	16
			0.092	1.5					
N-Sol C	Cl_2	90–120	<0.122	<3	†	0.2	0–850		0.33
Carb sol	CO_2	100	0.063	1.5	†	1.5	7,600		8

* Assumed to be prepared at 85 per cent, but water of hydration reduced to 79 per cent.
† Infinite dilution on admittance to system.

Results in Ordinary Mixing and Sedimentation Units

At present only one plant at the Biron, Wis., mill of the Consolidated Water Power and Paper Co., on the Wisconsin River, is still using straight mixing and sedimentation. Two other plants have installed suspended-solids process ("upflow") units. The Biron plant, with small dual flocculation tanks in series, followed by around-the-end sedimentation basins, has never been taxed to capacity. It was designed for 5 mgd and operates at about 4 mgd. The use of 3–5 ppm silica has improved operation and efficiency without increasing costs. More than 90 per cent of the color content is removed at all times. Winter operation is especially improved, with longer filter runs and better turbidity conditions in the effluent to the filters.

At the Wisconsin Rapids Div. of Consolidated, work with activated silica was initiated in 1944 in the old sedimentation plant. It was found much simpler to operate with silica when the plant was being taxed to capacity. A report (*4*), chiefly based on experience with Wisconsin River water, stated that the use of silica resulted in:

1. More effective coagulation during both warm- and cold-water periods, and especially during the cold-water period.
2. Larger and denser floc particles.
3. A saving of alum or alum and alkali during periods of easier coagulation.
4. Broadening the effective pH range of treatment and allowing the preparation of a treated water of somewhat higher pH.

5. Longer filter runs, especially during periods of cold water or high color, or both, when coagulation is difficult.

6. Buffering sudden chemical changes of water during spring runoffs or heavy rains.

7. Reduction of raw-water color by better than 90 per cent and producing water of somewhat lower color than in straight alum coagulation.

8. Production of a filtered water of higher quality, less turbidity, with a sparkle of spring water.

9. Prevention of "after-precipitation" of alum in the clear well during cold water periods when the reaction of alum is extremely slow and often comes to completion only after filtration.

10. Reduction of dissolved silica in the filtered water.

A similar test was made at the Appleton, Wis., plant on the Fox River in 1945. Results were again favorable. Since then this plant has been converted into an upflow type.

Weinberg, of the Nicolet Paper Co., at West DePere, Wis., on the Fox River, reports (*8*) for an old sedimentation plant:

Prior to our use of activated silica, our river water was treated with alum and bleach solution, and then filtered. The floc formed would not settle properly in our settling tanks, but floated on top, often to a thickness of 24 in. Whenever we had a hard rain, the treated water would still be so turbid and colored that we had to make deep-colored paper or shut the mill down—many times the latter being the case. Since using activated silica we have had no trouble settling the sludge. We do not have to change grades because of turbid or colored water. We have eliminated the rather frequent plugging of our filter beds.

Weinberg states that the amount of alum used has doubled since the adoption of the silica treatment, and more chlorine is also used. A small portion of sludge is circulated back into the incoming water to cause a more rapid formation of new sludge. The results indicate that conditions which constituted a serious, almost insurmountable, problem are certainly much better now, even though there has been a rise in chemical cost. Before the use of the silica an increase in alum was harmful. Sometimes excessive alum can reduce floc quality, but the silica prevented this from occurring and permitted the production of an acceptable water.

Westfahl, of Neenah, Wis., describes (*8*) the results at a plant where lime softening, chemical coagulation with alum, settling, and filtration are employed:

[Owing to greater] water consumption, we have increasingly felt the need of either [expanding] our settling capacity or [employing] a coagulant aid to [improve] the effectiveness of our present basins. The use of chlorine-activated silica was started on Mar. 27, 1954. Continuous activation and feeding [equipment is used]. Based on laboratory jar tests, an initial dosage of 3 ppm "SiO_2" was employed, along with [31 ppm] alum. Observation of results has since led to [the adoption of] a monthly average . . . alum dosage of [18.5 ppm], which was the . . . average [during] the last month of the trials. The silica dosage was maintained at 3 ppm. Trials above and below this amount proved this to be the optimum dosage.

Silica application is made into the line influent to the rapid mix chambers, [about] 100 ft down the line from the low-lift pumps. At the point of silica addition, a fine alum floc is already formed. Lime for softening and carbon for taste and odor control are added in the rapid-mix chamber.

With the addition of silica to the process, results were immediate and gratifying. A heavier, denser, better defined, and more rapidly settling floc could be observed in the settling basins. The effluent from the settling basins became clearer, with far less finely divided sus-

pended material, resulting generally in 25–30 per cent longer filter runs. Additional clarity and sparkle were noticed in the finished water. It is . . . believed . . . that a reduction in the amount of carbon needed to effect taste and odor control may be made, [owing] to the more complete removal of impurities from the water in the coagulation and settling processes with the use of activated silica as a coagulant aid.

No reduction in the amount of lime was made. We observe no perceptible change in our softening results at all, based on comparisons with periods prior to the use of activated silica.

These results for a softening operation indicate improved economy and efficiency, as well as the possibility of delaying the expansion of plant facilities.

In connection with the use of silica in sedimentation basins, a question is often raised concerning the difficulty of sludge removal. It is true that the settled and inactivated sludge is stickier and more compact when silica is used. Where hydraulic flushout is the only means of periodically cleaning a basin, the movement of the stickier sludge must be encouraged by flushing with greater water pressure. Being more compact, however, the sludge is not as fugitive, and is, therefore, more readily removed than a lighter sludge without silica would be.

Results With Upflow Clarification

In 1945 two 5-mgd rectangular clarifiers were installed at the Wisconsin Rapids mill to operate on Wisconsin River water, increasing the sedimentation plant capacity from 5.5 to 10 mgd. To operate these upflow units, it was necessary to carry a tough and fairly heavy slurry. Light, fragile alum floc alone will burst and "pop" to the surface, carrying harmful turbidity to the filters. The use of activated silica was found to be essential. The extra cost and labor involved was offset by the saving in alum. In addition, a better quality water was produced.

In order to provide a dense slurry, it is necessary to feed 5–7 ppm activated silica to the units under the impellers when operating close to capacity. This plant has operated at a higher pH than was possible with the old sedimentation basins. An evaluation of chemical economy has proved that the upflow plant operates with greater efficiency than the old sedimentation plant.

Because of bleach plant and general expansion at the Appleton Div. of the Consolidated Water Power and Paper Co., on the Fox River, it was necessary to expand the process water clarification facilities to such an extent that it became imperative to abandon completely the old 6-mgd sedimentation plant, except for the eight gravity filters used in conjunction with it. In its place, a new upflow clarifier was installed in October 1952. Pilot plant work, followed by actual tests in the old sedimentation plant, indicated that activated silica would be needed in the new plant, because, without it, the floc is fluffy, of low density, and not easily settlable. To produce and feed the 3–5 ppm silica needed, two continuous-activation units (Fig. 1) were chosen because they would save 96 per cent of the floor space required for a batch system. They have functioned very efficiently since installation. Recent papers (*3, 9, 10*) have dealt with their development and application.

In July 1949 a new iron removal plant for the city of Wisconsin Rapids was begun, after a considerable amount of pilot plant work to develop the most practicable method. It was found that lime and alum, supplemented with

1–2 ppm activated silica, produced the most favorable and consistent results with the organo-iron complex present in the soft well water involved. Based on pilot plant results, a full-scale 4.0-mgd plant was designed around upflow equipment. Extended, but somewhat interrupted, experimentation has indicated that a bit of alum with modest amounts of silica, or silica alone, may effect very good iron removal. The results are too preliminary to warrant discussion in this paper, but those interested are referred to a previous article (*11*) dealing with the Wisconsin Rapids plant.

At Neillsville, Wis., a surface water plant has been designed by the author and others, using upflow clarification to remove color and turbidity from the extremely variable Black River water. The plant has functioned efficiently since the beginning of operation, in August 1953. By varying the silica and alum dosages in accordance with the rapidly changing turbidity and

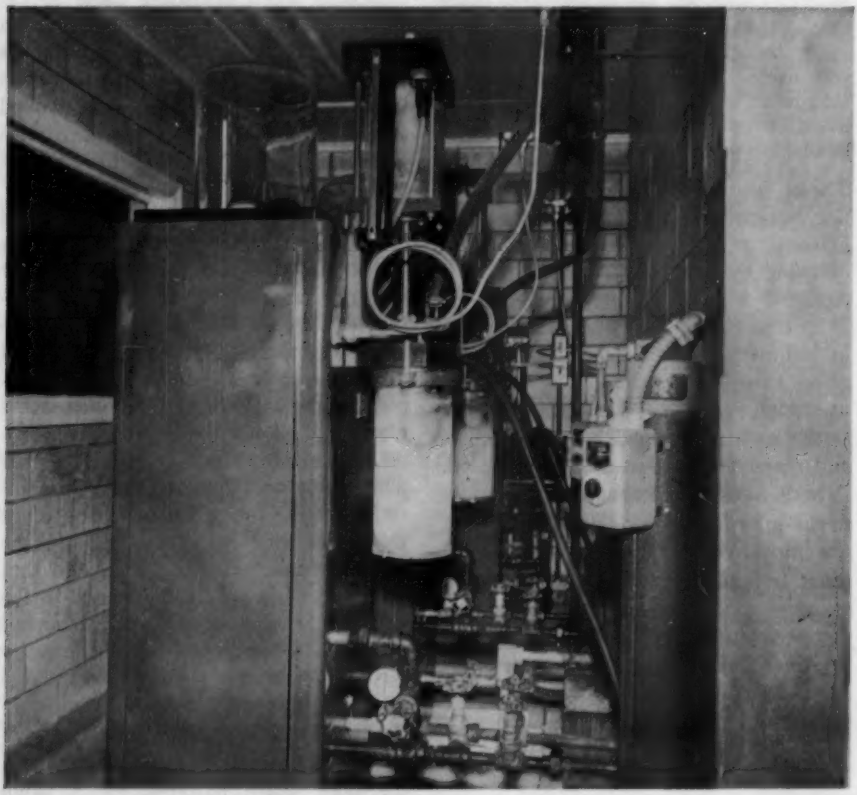


Fig. 1. Continuous-Activation Units

This rear view of the two units shows the gas dissolving and aging chambers. The equipment is marketed by Wallace and Tiernan Inc., under the trade name, "Silactor."

color characteristics of the stream, it has been possible to remove more than 95 per cent of the color in the clarifier, the remainder being removed in the filters. The batch method of feeding N-Sol D (sodium bicarbonate) is employed for the preparation of the silica sol.

Batch and Continuous Preparation

The choice of the method of sol preparation, whether batch or continuous, has to be made after the initial small-scale plant trials have been conducted. The matter resolves itself into a study of the space requirements and the available time and quality of plant personnel.

As previously stated, at a feed concentration of 1.0 per cent $^{-}SiO_2^{-}$, 100 gpd of solution is necessary to feed 1 ppm for 1 mgd. Thus, to feed 5 ppm in a plant operating at 5 mgd would require 2,500 gpd of solution. The production of this amount by the batch system can be accomplished in two ways (Fig. 2). One system (Fig. 2a) involves the preparation of a 2,500-gal batch, with a buffer supply tank available to provide a supply for a couple of hours between batches. With this arrangement, batches may have to be made up anywhere around the clock. The second system (Fig. 2b) involves the preparation of duplicate or multiple batches during one shift—for example, in daytime, when extra help is available. The required operating floor space—except for storage—is indicated for each method. For an installation of this size, it is desirable to store silicate from tank cars in bulk storage tanks rather than in barrels.

The first method is more suitable if every operator is trained to prepare the batches. The second is better adapted for operation by a utility man. Batch operation, being repetitive in nature, is more adaptable than continuous operation if plant personnel are not highly skilled.

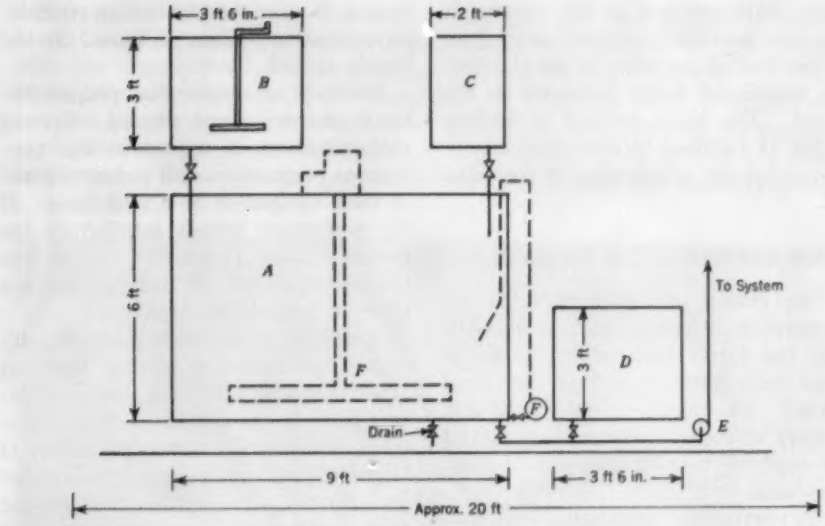
Methods of continuous preparation have been tried and proved. Certain manufacturers of apparatus for continuous preparation will permit the use of their equipment on a trial basis. If the equipment proves satisfactory, its purchase and permanent installation can be completed. Both liquid and gas reactant feeders are available.

Based on favorable experience with continuous operation during the past 2 years, plans are being made to investigate the extension of these processes to various other applications at Consolidated Water Power and Paper Co. plants. The elimination of the more cumbersome batch equipment is possible only when plant operators are conscientious. Once they understand the mechanics of continuous equipment and realize that it makes operation more efficient, they usually approve of it. Handling and storage problems connected with silica sols cease to exist.

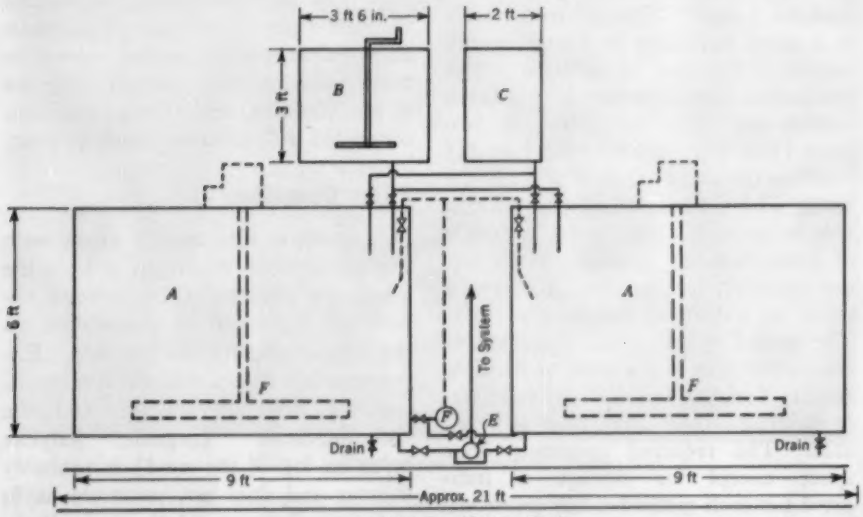
Filter Operation

A question that usually arises with regard to silica treatment is how the filters are affected. The author's experience is limited to coagulation on the acid or slightly alkaline side. Experience has shown that the floc reaching the filter is stickier, and the "schmutzdecke" (organic, jellylike layer on top of the sand) is probably thinner and does not penetrate as in ordinary alum coagulation. In backwashing sand filters, plenty of freeboard must be available in order to get a good lift, or else surface wash agitation is needed.

At Consolidated's Wisconsin Rapids mill, plugging of the sand filters was encountered after a few days of opera-



(a) With Buffer Tank



(b) With Two Makeup Tanks

Fig. 2. Alternate Batch Systems (5-ppm Activated-Silica Dosage for 5-mgd Plant)

A—2,500-gal makeup tank; B—200-gal reactant tank and agitator; C—65-gal silicate measuring tank; D—200-gal buffer tank; E—centrifugal supply pump; F—tank agitator or recirculating pump.

tion with silica. It was impossible to backwash at rates of more than 10 gpm per square foot. Palmer surface wash agitators were installed to eliminate this difficulty. Later the sand was replaced with an anthracite medium, because more filter capacity was needed. This medium has proved ideal and has decreased the wash volume and rates required to clean the filters.

When filter wash conditions are altered to suit activated silica, much greater filter runs can usually be expected, as less turbidity reaches the filters. All filters at the different divisions of Consolidated have been converted to anthracite media, not because of the use of silica, but because of the abuse they can take in loading. They remain clean for extremely long periods of time, without the necessity of frequent repair.

Probably the most thorough studies on filtration with silica are those of the South Dist. Filtration Plant at Chicago. This 576-mgd plant, designed to use the Baylis process, reports (*12*): "Without the use of silica, the water would not filter as clear as silica-treated water . . . . Water of better quality will be produced in the winter months by the use of the silica treatment, even though coarser sands and faster rates of filtration are used. When the considerable savings in plant costs are taken into consideration, the economy of using silicate is clearly indicated. From the standpoint of better quality alone, its use is justified."

Conclusion

The beneficial results often encountered when activated silica is used as a coagulant aid should be of interest to every water superintendent or chemist who is striving for improvement in the operation of his plant. Whether or not it seems necessary, an experimental trial with some temporary batch or continuous equipment, at very nominal expense, will indicate what the hydrosol may do. It may produce better economy, better efficiency, better organic removal, or some other benefit. It may be necessary to use the sol only during periods of difficulty, as when extremely high color, turbidity, or odor is present, or during times of heavy demand. Even if needed only for such limited periods, standby silica activation equipment may be economical.

References

1. Baylis, J. R. Silicates as Aids to Coagulation. *Jour. AWWA*, **29**:1355 (Sep. 1937).
2. Graf, A. V. & Schworm, W. B. Solution Mixture of Sodium Silicates Improves Coagulation. *W.W.Eng.*, **90**: 1514 (1937).
3. Black, C. A. Activation of Silica for Use in Water Treatment. *Jour. AWWA*, **45**:1101 (Oct. 1953). Griffin, A. E. Discussion. *Ibid.*, p. 1107.
4. Klinger, L. L. Improvements in the Coagulation of Surface Waters With Activated Silica. *Paper Trade J.*, **122**:15:44 (1946).
5. Henry, C. R. Characteristics of Activated-Silica Sols. *Jour. AWWA*, **41**: 551 (Jun. 1949).
6. Henry, C. R. Stability and Activity of Activated-Silica Sols. *Jour. AWWA*, **44**:49 (Jan. 1952).
7. Andrews, R. V. Continuous Production of Activated Silica With Carbon Dioxide Gas. *Jour. AWWA*, **46**:82 (Jan. 1954).
8. Personal correspondence (Aug. 1954).
9. Klinger, L. L. The Continuous Preparation and Application of Silica Sols in the Paper Industry. *Tappi* [Tech. Assn. Pulp & Paper Ind.], **37**:5:191 (1954).
10. Griffin, A. E. Preparation and Use of Activated Silica. *Jour. AWWA*, **46**: 571 (Jun. 1954).
11. Klinger, L. L. Iron Problems in Municipal Water Systems. *Proc. Wis. Wtr. Wks. Op. Short Course* (Apr. 1954).
12. *Eng. News-Rec.*, **128**:995 (1942).

Prestressed Concrete Tanks at East Bay

J. W. Trahern

A paper presented on Oct. 28, 1954, at the California Section Meeting, Long Beach, Calif., by J. W. Trahern, Supervising Civ. Engr., East Bay Munic. Utility Dist., Oakland, Calif.

THE East Bay Municipal Utility Dist. in California has in service at the present time 34 prestressed concrete tanks. They range in capacities from 0.2 to 5 mil gal and have a combined capacity of 79 mil gal. Three of the tanks are being utilized for sludge digestion in connection with sewage disposal, and 31 are being used to store filtered water in the water distribution system. Four additional prestressed concrete tanks are now being constructed for the district under contract, one of them with a capacity of 12 mil gal.

Construction of the district's prestressed concrete tanks has been distributed over a period of 22 years. All of the tanks have rendered excellent service. Maintenance costs have been low, practically insignificant. There has been no noticeable deterioration of the structures, and they have required no repairs of any consequence.

Comparative-cost studies made by the district's staff indicate a slight advantage in economy for the prestressed concrete tank over the steel tank, on the basis of ultimate costs. Owing to the probability of some inaccuracies in the assumptions used in the studies, it is not asserted that the conclusion indicated by them is firm. Nevertheless, it appears that the ultimate costs of the two types of tank are so nearly equal that the selection of either could be justified.

All the district's prestressed tanks have been constructed from designs prepared by its own staff. Some of the tanks have been built by district forces, while others have been built by private firms under formal contracts. It is believed that the district owns more prestressed tanks than does any other agency and that the 12-mil gal tank now under construction will have the largest capacity of any such structure in existence.

The design and construction of prestressed concrete tanks was first promoted in the United States by W. H. Hewett of Chicago in the early 1920's. The Hewett tank afforded some saving in both steel and concrete over the conventional reinforced concrete tank and proved to be less susceptible to cracking of the walls and to accompanying leakage. A substantial number of such prestressed tanks were constructed by various agencies throughout the country in the 1920's and 1930's. Experience with these structures has led to improved designs and construction procedures. At present the use of prestressed concrete tanks is increasing rapidly.

The basic principles being followed in constructing the walls of the modern prestressed tank have been utilized over a long period for constructing

wood barrels, wood stave pipe, and wood tanks. The wood containers have been made tight by applying tensioned circular steel bands to them, in appropriate quantity and distribution to maintain compression at the joint between the wood staves under load conditions. Tensioned circular steel bands are applied to the walls of concrete tanks in a quantity and distribution that will maintain circular compression in the walls under load conditions.

Wood tanks are generally considered to be temporary structures. Their steel bands are left exposed, and tension in the bands may be adjusted from time to time as it becomes necessary on account of losses of stress. Wood has substantial tensile strength in the direction of the grain. The staves of a wood tank will successfully resist the bending moments that are produced in them by tensioning of the circular tank bands. As the concrete tank is expected to be a permanent structure, its tensioned steel elements are embedded in concrete, for protection against corrosion, and are not accessible for adjustment of stresses.

Because concrete has comparatively little tensile strength, vertical prestressing of the walls of concrete tanks is frequently utilized to take care of bending moments produced by horizontal prestressing and modified by liquid loading. In short, the successful construction of the walls of concrete tanks demands rigid and careful design and carefully controlled construction procedures, while the walls of wood tanks may be successfully constructed on the basis of comparatively crude analyses. The prestressed concrete tank must be originally built so that subsequent changes in stress resulting from plastic flow of the concrete and from creep of the steel will not necessitate adjustments in the prestressing elements.

Bar-stressed Tanks

The Hewett tanks of the 1920's were prestressed by tensioning steel bands around the peripheries of the walls. The bands consisted of mild-steel bars threaded at the ends and coupled with turnbuckles. Tensioning was accomplished by running up the turnbuckles on the threaded bars. The tank walls were not prestressed vertically, but were equipped with a nominal amount of vertical reinforcing steel bars.

Hewett tanks were usually equipped with dome roofs supported on the peripheries at the tank walls. The Hewett design provided prestressing forces calculated to balance the horizontal thrust of the dome roof, to support the liquid loads on the tank walls, and, at the same time, to retain a small amount of ring compressive stress in the walls at all elevations. Losses in stress resulting from creep in the steel and plastic flow of the concrete received no recognition in Hewett's design. More recently such stress losses have been provided for in the designs of prestressed tanks.

The first few prestressed concrete tanks constructed by the district included mild-steel round bars and turnbuckles for the prestressing elements, as did the Hewett tanks, and the designs therefore made no provision for losses of stress. These tanks are now 20 years old or more and are giving excellent service. If ring tension has developed in the walls of the tanks as a result of stress losses, the quality of the structures has not been impaired

from the standpoint of the service they are rendering at present.

In the middle 1930's the district's engineers discovered that considerable economy in the construction of its concrete tanks could be effected by modifying the designs to provide for the use of higher-strength square bars instead of mild-steel round bars for the prestressing elements, and to provide for coupling the bars at special fabricated beams placed at intervals around the tanks. The advantage of the high-strength steel lay in the fact that, although the price per pound was greater, the required prestressing force could be produced with less steel at a lower total cost. The use of square instead of round bars, and of coupling beams instead of turnbuckles, resulted in a substantial saving in the cost of installation of the prestressing elements. The round-bar and turnbuckle arrangement was comparatively difficult to install. A great deal of effort was required to prevent the round bars from rolling when torque was applied at the turnbuckles to run them up on the threads. In the square-bar and coupling-beam arrangement, the bars were run through properly spaced holes in the beams. The beams were made continuous from the bottom to the top of the walls, and the bands were thereby securely supported in place. The bars were tensioned by running up nuts on their threaded ends against the beams. Each end of every bar was upset over the threaded portion in order to obtain the proper steel area under the thread. The bearing of the square bars on the wall prevented them from turning when torque was applied to the nuts. A further advantage of this new arrangement of prestressing elements was realized: the relation between the torque applied at the nuts and the tension produced in the square bars was far more uniform than was the relation between the torque applied to the turnbuckles and the tension produced in the round bars. This made possible a more accurate prestressing job with the square bars, nuts, and coupling beams.

The district has in service a very substantial number of prestressed concrete tanks in which the horizontal prestressing elements consist of bands of coupled square steel bars, with a minimum ultimate strength of 85,000 psi. Vertical prestressing was not employed in these structures, but a nominal amount of vertical reinforcement was included in the tank walls. The tanks have consistently performed well.

Wire-stressed Tanks

In the middle 1930's a New York company began to promote the use of high-tensile-strength steel wire for prestressing concrete tanks. This company developed and utilized a machine capable of winding the wire helically on the tank walls under high tension at a fast rate. The method provided some economy in the cost of the prestressing operation. It has been claimed that a superior structure can be produced by use of the higher-tensile-strength wire. Within the past 20 years a large number of wire-wound prestressed concrete tanks have been constructed throughout the United States and in other countries.

As has been mentioned, Hewett's designs for prestressed tanks made no provision for losses of prestress that might come from shrinkage of the concrete, plastic flow of the concrete, and creep of the steel subsequent to the prestressing operation. There is

evidence indicating that, in order to maintain the walls of a tank in permanent compression, it is essential to include in the prestressing steel a substantial excess of stress over that required to meet design loads, to absorb subsequent stress losses. The surplus stress is almost a constant and is correlated with the working stress of the concrete.

High-strength steel rods have a minimum yield point of 70,000 psi and can safely be stressed to about 50,000 psi. After deducting from this figure about 30,000 psi for excess stress, as is current practice for wire-stressed tanks, there remains for working purposes only about 20,000 psi. This means that, with high-strength prestressing rods, only about 40 per cent of the safe working strength of the steel would be utilized to carry design loads.

In current practice, special high-strength steel wire is used for prestressing tank walls both vertically and horizontally. Various brands of wire are available with ultimate strengths ranging from 200,000 to 250,000 psi. These wires may be safely stressed to seven-tenths of the ultimate strength, or, say, 140,000 to 175,000 psi. Deducting from these values 30,000 psi for excess stress required, 110,000 to 145,000 psi remains for working purposes. Consequently, with the high-strength wire, approximately 80 per cent of the safe working strength of the steel is utilized to carry design loads.

The district had its first wire-wound tank constructed in 1951. Since then eight more such tanks have been built for the district. Only two of the nine have been prestressed vertically. All are performing satisfactorily. It was not, however, because of any dissatisfaction with the quality of the bar-stressed tanks that the district in 1951 began building wire-stressed tanks and has continued to do so since. The first few wire-stressed tanks were constructed after calling for bids on the wire-stressed and bar-stressed tanks as alternates. As the low bids were consistently offered on the wire-stressed structures, it became obvious that there would be no point in continuing to offer the bar-stressed tanks as alternates to bidders. For several years now, only the wire-stressed structures have been offered.

It appears likely that the wire-stressed tank may be somewhat superior in quality to the bar-stressed type. In the former, positive provision is made for substantial losses of the prestress at small cost. In the latter, such provision could not be included at reasonable cost. The district's long experience with bar-stressed tanks has revealed no deterioration in the quality of the structures due to stress losses. This durability can probably be traced to a number of factors. Initial stresses in both steel and concrete have been kept low—30,000 psi in the steel bars of 85,000-psi ultimate strength, and 500 psi in the concrete of 3,000-psi strength at 28 days. Normally the tanks carry a substantial water load, resulting in very light concrete stresses almost all of the time. Under the circumstances, creep of steel and plastic flow of concrete can be expected to be small. Measurements of changes in stress made on structures of the district seem to substantiate this view. The stress changes in the bands of the bar-stressed tanks, as determined by measurement with an 18-in. extensometer, are so small as to be within the

range of accuracy of the instrument. One can, however, conceive of conditions under which stress losses in tanks may be of substantial magnitude. Provision has been made in all the district's wire-stressed tanks for stress losses in the steel of the order of 15 per cent. In these structures, measurements have indicated losses ranging up to 20,000 psi and averaging about 10,000 psi.

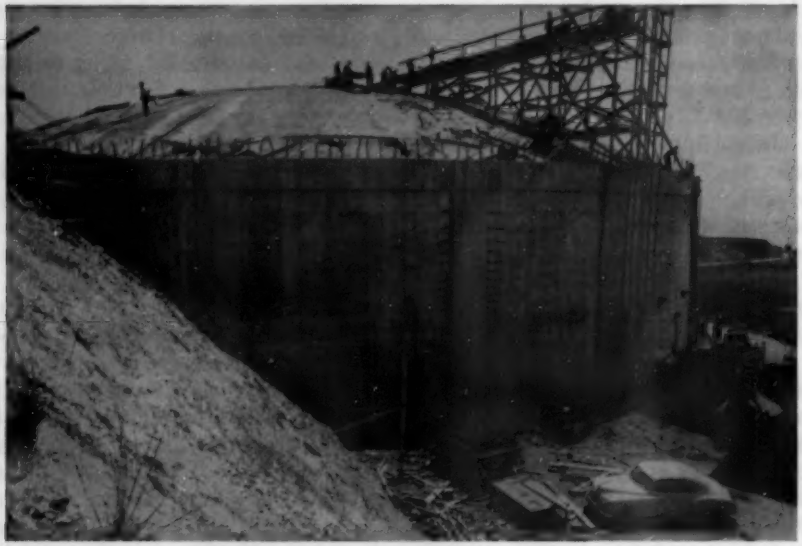


Fig. 1. Richmond Reservoir

This 12-mil gal structure, now nearing completion, will be the largest prestressed concrete water storage tank in the world. The prestressing bands consist of high-tensile wire cables contained in flexible metal hose embedded in the concrete walls of the tank.

Recently the district, in its plans and specifications for prestressed concrete tanks, has been including alternative designs for horizontal prestressing arrangements. One of the designs is based on helical winding of high-tensile-strength steel wire, under tension, upon the walls of the tanks to obtain the required prestress. After the wire has been installed, it is covered with gunite for protection. The other design is based on the use of tensioned wire cables to obtain the prestress. The cables, assembled in flexible metal sheaths, are cast within the tank walls, except at the ends, where they protrude at the pilasters. They are tensioned by pulling the ends against the pilasters with hydraulic jacks. The ends are anchored at the pilasters, and the cable sheaths are filled with grout to protect the wires from corrosion.

The object of offering the alternative designs has been to stimulate competition in bidding for the construction

contracts. Both methods of prestressing require patented equipment, and monopolies in its use are involved, but bidding on the alternatives has been very competitive. Of the four tanks now under construction for the district, three will be stressed with cables and the other with wire winding. The 12-mil gal Richmond Reservoir, now nearing completion, is the first embedded cable-stressed tank project ever started in the United States (Fig. 1).

Design and Construction

A discussion of the district's prestressed concrete tanks would not be complete without mention of some of the important design and construction features. In this connection, an effort will be made to cover briefly some points of primary interest to those who may be concerned with building such tanks.

The principal structural elements of the prestressed concrete tank are the foundation, the floor, the wall, and the dome roof. In current practice, two of the elements, the wall and the dome, are prestressed. The foundation and floor are generally constructed under more conventional standards. Although the prestressed wall and dome appear to attract greater interest among engineers, substantial leakage from prestressed tanks is usually found to be the result of inadequate floors and foundations. Leakage through the walls has seldom been severe, and the author knows of no case of failure of a prestressed dome.

Tank Walls

Some of the principal elements requiring careful attention for proper design and successful construction of prestressed concrete tank walls are summarized below:

1. Dense concrete, without honeycomb or shrinkage cracks, is highly important. A well designed concrete mix of low water-cement ratio, careful placement and thorough vibration of the mix, and thorough curing of the concrete are essential.

2. The walls should be constructed of panels separated by vertical construction joints, each panel a continuous pour from bottom to top. The panels should be short enough horizontally to avoid the development of shrinkage cracks within them. Horizontal construction joints may result in differential shrinkage within the panels and locked-in stresses, rendering it impossible to achieve the anticipated distribution of prestress in the concrete.

3. There may be some advantages to the use of high-tensile-strength steel for prestressing the walls. Cold-drawn wire, either stress relieved or not, is currently being utilized almost exclusively for this purpose. The wire is readily available in ultimate strengths ranging from 200,000 to 250,000 psi. It can be stressed to seven-tenths of its ultimate strength safely. After stress losses, a major portion of the strength of the wire is available for supporting design loads. This is not true of lower-strength steel. It also appears that there is an economic advantage in using the high-strength wire.

4. Horizontal prestressing of the wall should be designed so that overstressing of the concrete will not occur, and also so that some circumferential compression will be retained in the concrete after stress losses with a full tank. In line with this considera-

tion, an appropriate thickness of wall and a proper quantity and distribution of prestressing steel must be calculated for any tank, taking into account the elastic deformation of the structural elements. The arrangement of horizontal steel may be determined on the following bases:

a. Original tensioning of the high-strength steel will produce a maximum stress therein of seven-tenths of its ultimate strength.

b. Stress losses of approximately 15 per cent may take place in the steel wire over a period of time. For lower-strength steel, the loss may be a greater percentage.

c. At any elevation on the tank wall, sufficient steel should be installed to take the water load at that elevation and, at the same time, to maintain some circumferential compression in the concrete after anticipated stress losses.

d. In the wire-wound tank, the wire is tensioned before it is placed against the wall. As a result, the stress distribution along the wire is substantially uniform. In designing the district's tanks, allowance is made for a variation of 10,000 psi above and below the specified nominal initial stress in the wire.

e. In the cable-stressed tank, friction develops along the cables as they are tensioned, owing to their bearing against the cable sheath as they elongate under stress. As a result, the stress along the cables varies by a substantial amount. This variation must be taken into account in the design. Measurements made on the district's first cable-stressed tank indicated an average friction factor of 0.6 between the cables and sheaths, and a variation in stress along the cable of approximately 50 per cent of the maximum. A reasonably uniform distribution of stress in the concrete can, however, be attained. The cables must span two pilaster intervals. By staggering cable anchorages in such a manner as to give an arrangement in which the cables are alternately centered on and anchored at each pilaster, the prestress in the concrete will be substantially that produced by the average stress in the cables.

5. Vertical prestressing of the walls is done with embedded cables in sheaths, similar to those used for horizontal prestressing. The cables are straight and are, therefore, not subject to serious friction forces and accompanying variation of stress. Sufficient vertical prestressing is provided in the tank walls to take care of bending stresses produced by the horizontal prestressing and by the water loads. As the horizontal prestressing proceeds, the walls slide radially inward on the footing. Friction between the footings and walls generates bending stresses in vertical wall elements. When the tanks are filled, the walls move radially outward, resulting in a reversal of the bending moment. The vertical steel is centered in the wall to provide for bending in opposite directions.

6. The thickness of a tank wall at any elevation should be sufficient to support the initial tensioning of the prestressing steel without the development of stresses in the concrete which might exceed safe working stresses.

7. All the district's prestressed tanks are provided with radially oriented keys at the bottom of the walls, extending into the footings. Under this arrangement, wall panels may freely move radially on the footings but are prevented from moving tangentially.

Thus, horizontal loads on the tanks are supported by reactions at the shear keys directed tangentially to the circular walls at all locations.

Tank Domes

The slab dome is the most economical roof for a circular tank. The district is having concrete dome roofs constructed on its tanks at a cost of about $1.40 per square foot. The stresses in a hemispherical slab dome are not significantly affected by the elastic property of the material of which the dome is constructed, and the character and magnitude of the stresses in such domes are easily computed. This is far from true of the normal segmental dome. On the latter, the stresses caused by the elastic character of the abutment are many times as large as the stresses in the corresponding part of the hemispherical dome. In parts of the structure, the character of the stresses is reversed, causing severe bending and endangering its safety. A segmental dome may be equipped with an abutment providing the same reaction as would be furnished in a hemispherical dome to the corresponding segment. By applying prestressing bands of steel properly adjusted at the periphery of the segmental dome, stress conditions similar to those prevalent in the corresponding segment of the hemispherical dome will be produced.

The dome for the district's 12-mil gal Richmond Reservoir is 200 ft in diameter, rises 26¾ ft, is 4½ in. thick over most of its area, and was constructed to a radius of 202 ft. Domes on smaller tanks are thinner. All domes have been constructed with a nominal amount of reinforcing steel as a precaution.

Tank Floors

As has been pointed out, most leakage from prestressed concrete tanks has been through the floors. The district is currently constructing its tank floors in accordance with a unique design that has shown merit. The design is calculated to provide satisfactory watertightness and thorough leakage control at comparatively low cost. The essential features of such a floor are:

1. A positive underdrain system consisting of tile drains in trenches and a gravel blanket over the subgrade 2½ in. thick. The drains are extended to discharge at some convenient location where no damage will result.

2. A compacted base, 4 in. thick, of asphaltic plant-mixed paving, over the gravel blanket.

3. An impervious membrane of asphalt over the compacted base, ¼ in. thick. This membrane has, to date, been constructed of an asphaltic emulsion containing asbestos fiber and has been applied by spraying.

4. A 6-in. thick concrete slab over the impervious membrane, with construction joints at 12-ft intervals. The construction joints are sealed by packing with cement mortar.

Foundations

Foundations for prestressed concrete tanks should preferably be nonyielding to a high degree. In this connection, the district has been fortunate, as such foundations have been readily available. All tank storage is located in a hilly area. It is characteristic of the hills around the San Francisco Bay region that the bedrock is generally near the ground surface. It has been necessary, however, to avoid locations

on the extensive fault zones in the area.

Sealing Rings

Sealing of the joints between the floor slabs and walls of prestressed tanks has frequently presented problems. The general practice is to use cement and sand mortar with an admixture of iron dust for the seal. This method has not worked out satisfactorily on some occasions. A rubber seal ring, used on most of the district's tanks, has proved excellent but is comparatively expensive. In the district's installations, the walls and the peripheries of the floor slabs rest upon common circular concrete footing rings. An annular space, a few inches wide and 9–12 in. deep, between the edge of the floor slab and the wall, results in each structure. Grout is placed in the bottom portion of the space and an assembly consisting of a strip of rubber with steel half-rounds or ovals on the top and bottom sides is inserted above the grout. The ovals and rubber are drilled for studs at short intervals. By drawing the steel pieces together with the studs, the rubber strip is spread to bear against the side boundaries of the annular space with sufficient pressure to prevent leakage at the joint. The joint will remain tight under some movement of the wall. This may not be true of the mortar-sealed joint.

At present the district is experimenting with a joint seal far less expensive than the rubber one just described. In a 5-mil gal tank recently put into service, an asphalt and latex mixture was placed in the space between the floor and wall to form the seal, which appears to be functioning satisfactorily. The same sort of seal will be installed in three more tanks now under construction. In each, arrangements have been made to leave space in the top portion of the joint to install a rubber seal if it is later found necessary to do so.

Conclusion

The district has plans for substantial expansion of its filtered-water storage facilities during the years immediately ahead. Its past experience with prestressed concrete tanks has been very satisfactory from the standpoint of both the quality of the structures and the cost thereof. Contractors with experience in building the tanks are located within the district, and competition in bidding for the construction contracts is good. Some of the contractors maintain sets of forms required for the work. It is believed that, with the gradual improvement in design that has taken place, the later structures are somewhat superior to the earlier ones. Indications are that the district will continue to construct prestressed concrete tanks on a substantial scale.

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NEPTUNE METER COMPANY
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NEPTUNE METERS, LTD.
1430 Lakeshore Road • Toronto 14, Ontario

Branch Offices in Principal American and Canadian Cities

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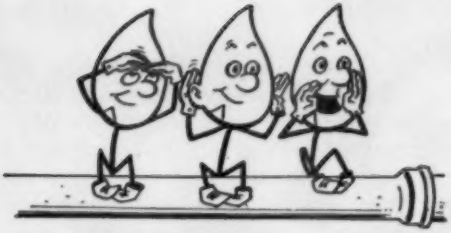


Percolation and Runoff

The banding of the brass this year saw 37 of the Association's 40 directors gathering in the not too ivory tower of New York's Park Sheraton Hotel last January 16–18 to check the AWWA score for '54 and precontrive its '55. An idea of what was accomplished has already been given in the January 31 letter to all members, and more detailed reports will follow in next month's JOURNAL, but it remains for someone to point out that there is no "l" in the terminal word of the Board's favorite self-characterization: "all work and no pay."

The "l," of course, is raised during intermissions only, starting this year at the opening luncheon when past-president Vic Weir paid off his annual budget bet to Finance Committee chairman Bill Orchard with a turkey saddle (not to be confused with a saddle of turkey), the significance of which was slightly modified in the explanation by the presence of ladies. Next break came during the dinner hour, when Illinois' Ed Alt unleashed so much enthusiasm in his preview of next June's Chicago Conference that only two of the 70 on hand bet their bottom dollars on a registration total of less than 2,000, while two exuberated to a point considerably above 3,000, with the average a couple hundred above the present record.

Monday's serious attention to chores was interrupted only by a brief luncheon ceremony during which a representative of AWWA's Good Turn Society turned on two of the Board's needliest. Wendell LaDue, who had just finished his report on the extensive activities of the Water Works Administration Committee, was provided with a pair of "Refuge" glasses (with built-in wide eyes) and a set of oversize ears to permit him to rest out the balance of the meeting without losing his normally alert and attentive look. And Wylie Gillespie of Florida was presented with the "real" secret of the California wet-barrel hydrant—its name "Fido," one of whose legs was equipped to react appropriately to a squeeze on a waterfilled rubber bulb. But it was on Monday evening, with no session scheduled, that the town first felt the full impact of AWWA Boardom, the sights and shows of the Big City constituting the rather more "l"-evating agenda.

Even so, all were on hand for a final session on Tuesday preliminary to accepting the plaudits of some 350 New York Section members and friends gathered at a special luncheon meeting to honor them. And then, just about 50 hours and two good weeks' work after the Sunday noon roll call, the brass undertook its official disbandment until next June at Chicago—all out all in.

(Continued on page 30 P&R)

The Canadian Section has opened an office at 72 Grenville St., Toronto, for the purpose of improving its membership services. The office will be shared with the Canadian Inst. on Sewage and Sanitation, and a full time executive assistant will be in charge.

The North Central Section of AWWA is the new name for what used to be called the Minnesota Section. In making the change, which became effective January 1, the Section merely acknowledged the fact that Minnesota had long been a misnomer, because of the regular and active participation of residents of North and South Dakota —states which are in the official territory of the Section—and also some from the neighboring Canadian provinces.

Something significant should surely have been made of the fact that the tenth anniversary—the one just celebrated by fluoridation on January 25—is traditionally the "tin or *aluminum* anniversary." What with all the excitement engendered by antifluoridationists concerning the sinister plot purportedly cooked up between the fluoridation-promoting Public Health Service and the fluoride-producing Aluminum Company of America by Oscar Ewing, exhead of the one and excounsel of the other, we might have expected at least a "March on Grand Rapids" to stamp out the "dastardly communistic scheme" which fluoridation's "Aluminum Jubilee" actually, if perhaps unwittingly, represents. Still, having predicted the demise of every water drinker in that city long before this, those most likely to organize such a march could hardly have relished the thought of walking in on a dead city.

On the other hand, something significant has surely been made of the ten years that have gone into the alumination of the program—an average of more than 2,000,000 population and more than 100 communities per year having been added to the list of those receiving fluoridated water, to make the net total on January 1, 1,034 communities and 20,229,146 population served. The fact that this growth hasn't been achieved entirely in an aura of sweetness and light may actually be more obvious than it should be, for more often than not fluoridation has been initiated without the excesses of rancor and unreason that have characterized the most publicized programs. Since November, of course, the pressure has been heavy, with ten communities rejecting fluoridation in popular referendums, while only five voted for it. And in New Orleans, La., and Des Moines, Iowa, where water boards control the decision, the answers have been "no, no, no" and "no," respectively. Meanwhile, the courts have been considerably kinder, giving the program a unanimous vote of constitutionality. First the US Supreme Court refused to review a decision by the Louisiana Supreme Court in favor of fluoridation on the basis that no substantial federal question was involved, just as it had refused to upset a similar California Supreme Court decision in a case concerning San Diego. Then the Washington Supreme Court added its weight to the growing body of opinion favoring fluoridation by affirming the ruling of the Superior Court of Lewis County in the case of *Kaul* v. *City of Chehalis*, concerning the constitutionality of the procedure.

In the ten years that fluoridation has been with us, a tremendous amount of

(*Continued on page 32 P&R*)

THE WORM THAT TURNS THE LOCK THAT LIFTS!

A strong, effective lock, insuring safety for the meter and the pedestrian.

A powerful screw-jack with handle to force the lid open even when frozen down.

When it comes to opening meter boxes that are sealed shut with ice or dirt, nothing beats the Ford Meter Box Cover fitted with the Lifter Worm Lock. All it takes is a simple twist of the wrist. The powerful worm leverage does the rest and the key serves as a handle for lifting the lid. Send today for full information about this and other time-saving Ford meter servicing devices.

THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

FORD

Wabash, Indiana

(*Continued from page 30 P&R*)

information and a great deal more misinformation has been published. Unfortunately, not even everyone who should has been able to distinguish the one from the other. Consider this explanation in the lead editorial of a recent issue of the Altoona, Pa., *Mirror*, for instance:

> Fluoridation is a system of using chlorine in a weakened form to purify the water. The substance is a pungent, awfully smelly, corrosive gas, and plants using the additives get numerous complaints about ill-smelling water. . . . Experts agree that if the water tastes bad, it's healthy, and if it tastes good to the user, it's no doubt impure, lacking germ-killing chemicals.

New York newspapers in their current educational campaign are doing considerably better than that, but at the moment the nation's largest city isn't close enough to adopting fluoridation to merit the full attention of those who have taken it upon themselves to prove to the nation that fluoridation is not only illegal and immoral, but undemocratic and unsafe as well. The fact that the dentists, in favoring it, seem to be anxious to cut themselves out of some business is probably what makes the ill-informed suspicious and, thus, susceptible to almost any explanation that is nondental, however nonmental it may also be. At any rate, those who are better informed and who have, most conservatively, held back their approval will now have the ten-year record they indicated to be necessary to judge the value and wisdom of the procedure. It will be interesting to see how many are convinced and how many will discover that 15, or 50, or perhaps 500 years are actually necessary to a satisfactory trial.

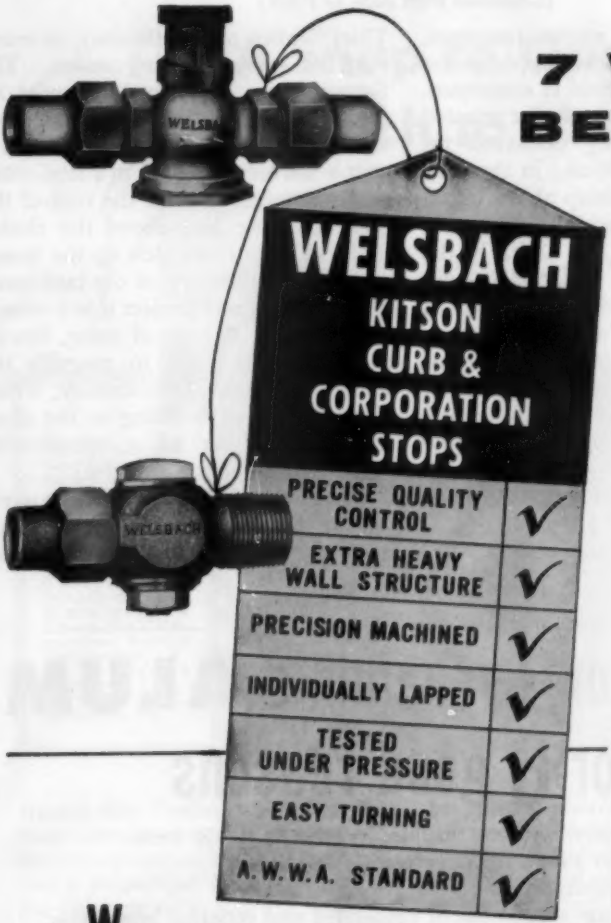
Significant at the very least, after these ten long years, ought to be the fact that a lot of people killed first by the addition of alum to their water supplies and then by chlorination have managed to survive still another killing. Murder, it seems, is something one can be tried *for* only once, but *by*, innumerably.

Like Canadian football, the Canadian tooth brawl is very little different from that in the U.S., although the scoring has been a great deal lower. Partly this has resulted from the fact that there were no additional adoptions for 6½ years after Brantford, Ont., began fluoridating in June 1945 and partly because the approach there has been generally more conservative. But the same arguments and the same practices are current, and the results of public referendums just as unpredictable. Thus, when Saskatoon and Regina voted last year, the former said yes, the latter no. Brandon, Man., meanwhile, made its plans to get into the game. Dentist, anyone?

Lowell E. Sennet, Chicago district manager for A. P. Smith Mfg. Co., will also represent National Water Main Cleaning Co. in Illinois, Indiana, Wisconsin, and Michigan. The National sales office is at 122 S. Michigan Ave., Chicago 3.

Recent administrative changes in Atlas Mineral Products Co. include the institution of a profit-sharing and pension plan for all employees, and the following promotions: Joseph A. Snook, from vice-president to executive vice-president; Eugene Kirkpatrick, from Eastern regional to general sales manager, and Kenneth T. Snyder, from Western regional to assistant sales manager.

(*Continued on page 34 P&R*)



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Welsbach-Kitson Curb and Corporation Stops are made with built-in quality . . . designed to give permanent top performance. Extra heavy wall structure means many added years of underground service—and they're precision machined with each plug accurately ground into its own valve body for easy turning. Each stop is tested individually under pressure before shipment. All of them conform to the standards of the American Water Works Association and can be inserted by any standard tapping machine.

Welsbach-Kitson craftsmanship means long life and faithful performance . . . and you will get the real satisfaction that only precision manufacture and premium quality materials can give. Insist on Welsbach-Kitson when you order water service bronze.

THE WELSBACH CORPORATION
KITSON VALVE DIVISION
Westmoreland & Stokley Sts. • Philadelphia 29, Pa.

(*Continued from page 32 P&R*)

Resourcefulness, unlike resources, has never been in short supply as far as the water works field is concerned. Thus, we have come to take for granted the kind of ingenuity displayed recently at Hopkins, Minn., in the conversion of a bank holdup alarm into a foolproof pumping station warning system, or at Temple City, Calif., in the home-making of a periscopic gage-viewer to permit one of the clerks of the Sunny Slope Water Co. to keep check on the water level in a distant reservoir without moving from her desk. About the Hopkins burglar-beater we have no details, but imagine it to be one of those simple make-do devices which almost every water works uses in some phase of operation—undoubtedly screaming "Stop Thief!" when pump efficiency, or economy, or safety is being stolen. The Sunny Slope See Level, likewise an inexpensive substitute for a much more elaborate control device, consists of a couple mirrors mounted in a steel stack that protrudes through the roof of the office building just above the clerk's desk. The mirrors pick up the image of a sight gage on top of the tank some distance away and project it to a viewer at the desk. In case of smog, there's a telescope at hand to magnify the image (something, incidentally, which the device itself is doing to the clerk in depriving her of a considerable amount of slimming exercise).

But these are just the ordinary miracles of our ingenious at work, seldom even reported. What always surprises

(*Continued on page 36 P&R*)

Depend on Cyanamid's ALUM for 6 good reasons

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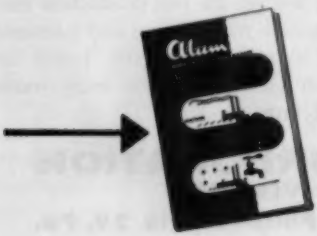
3. It forms floc rapidly.
4. It gives maximum adsorption of suspended and colloidal impurities.
5. It causes minimum corrosion of feeding equipment.
6. It is available in granular form or in the new easy-to-use liquid form.

For a copy of "Alum—Commercial Aluminum Sulfate," please send us your name and title on company stationery—and would you also mention where you saw this offer?



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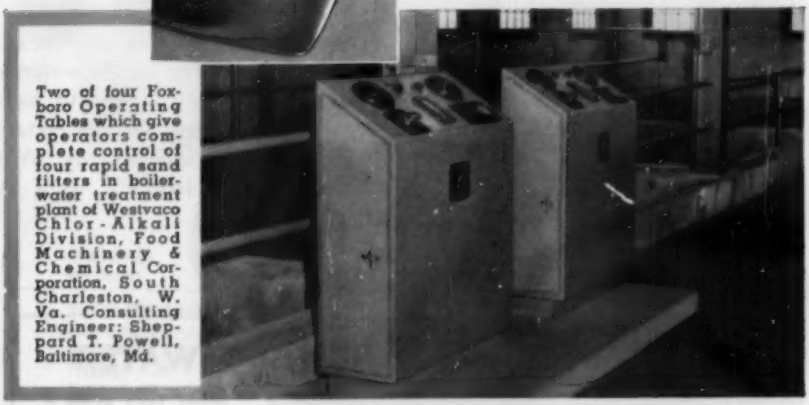
A Snap to Operate... a Cinch to Maintain!

...Foxboro "Fingertip" Control for rapid sand filters



Two of four Foxboro Operating Tables which give operators complete control of four rapid sand filters in boiler-water treatment plant of Westvaco Chlor-Alkali Division, Food Machinery & Chemical Corporation, South Charleston, W. Va. Consulting Engineer: Sheppard T. Powell, Baltimore, Md.

Here's the Foxboro System that puts complete control of every filtration operation right at the operator's fingertips! A simple turn of the selector switch starts filtration or backwashing at pre-set rates; shuts off influent, or by-passes effluent to waste. In addition, rates can be *re-set* right at the master operating table.

Maintenance of this modern, all-pneumatic system is "tops" too. Rugged d/p Cell Transmitters detect and transmit loss-of-head and filtration rate measurements . . . are unaffected by backwash and sand . . . need no drum, pulley, or cable servicing. Control valves are rubber-lined . . . provide lasting, tight shut-off operation.

Get top efficiency on *your* filter runs the *economical* way. Investigate Foxboro "Fingertip" Control. It's easier to install, to operate, to maintain. Write for complete information in illustrated Bulletin.

THE FOXBORO COMPANY, 162 NORFOLK ST., FOXBORO, MASS., U. S. A.

FOXBORO
Reg. U. S. Pat. Off.

Automatic Control for Rapid Sand Filters

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

(Continued from page 34 P&R)

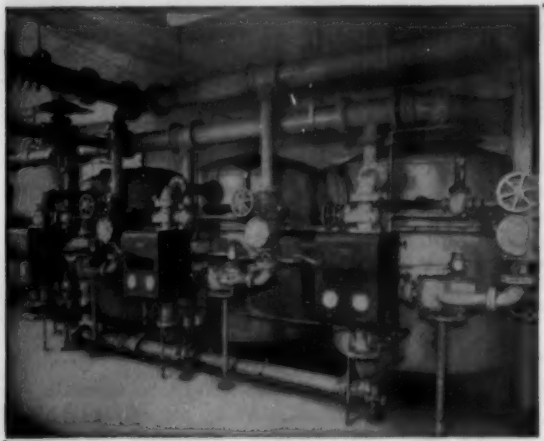
us much more is evidence that mere contact with water work elevates even the layman to epics of ingenuity. Consider, for instance, the cunning of one Harry C. Stille, chairman of the lake committee of American Legion Post 441 of West Long Branch, N.J., in suggesting this solution to the aggravating lotus plant infestation in the municipality's Franklin Lake:

1. Lower the lake level by 1 ft to expose the plant stalks.
2. Wait for a freezing spell to grip the stalks in ice.
3. Let the ice thicken to about 6 in. and raise the lake level.
4. As the water and ice rise, the ice-imbedded stalks will be uprooted.
5. Drain the water.
6. As the water flows out, the ice will drop, crushing the plants.
7. The ice left will freeze the roots, killing the plants.

Or imagine the inspiration of lumberman Alan Chase of Laconia, N.H., in designing diapers for his horses to make possible logging of a watershed area without polluting it. These dobbin-size didees are hung in the proper position from the harness hip-strap and breeching, one side of the canvas bag of which they consist being strapped to the tail, thereby to be opened automatically as the occasion arises. Chase horses on the watershed jobs, of course, are limited to mares.

Remaining horsey, we can certainly tout Ingenious Solution, by Water Worker out of Necessity, as a sure thing.

(Continued on page 38 P&R)



WATER PROBLEM?

Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

If you have a water problem of any size or type—write us. With over 50 years of experience—conditioning water—We Can Help You

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AWWA Standard Bell Spigot Watermain Fittings—24 through 36 inch.

Available Immediately From Stock

AWWA Approved Short Body and Mechanical Joint Watermain Fittings—4 through 12 inch.

AWWA Standard Bell Spigot Watermain Fittings—2 through 24 inch.

TRINITY VALLEY IRON AND STEEL CO.

Phone PErshing 3141 Fort Worth, Texas P. O. Box 604

(Continued from page 36 P&R)

Sign of the times was the one that appeared on the lawn of the Don Mitchells of Ponca City, Okla., whenever their sprinkler was in action last summer:

Lest you tell us where to dwell
This water comes from a private well.

Were we a Ponca Citizen, we'd be tempted to picket the place anyway, with our own sign just as much "of the times":

To flaunt your verdure in our midst
Just proves you are a communist.

Actually the way things have been in the Southwest these past summers, even moisture from Moscow would be welcomed.

Frogs in the throat are ordinarily no great problem—nothing that a good strong haaarrrrumph won't take care of—but when they stem from tadpoles in the tap water, it's time for stronger measures. Such was the situation faced by the Alexandria, Va., Water Co. last summer when five of its customers appeared with prima-facie proof of pollywog problems. Measures immediately taken included draining the distribution reservoir from which the wiggling water had been drawn, flushing the mains between the reservoir and the befrogged homes, and then screening the outlets before the reservoir was returned to service. Best guess as to cause was that the froglets had entered the system when the severe drought conditions of the weeks previous drew the level of the water down to a point where the near-surface swimmers arrived at outlet altitude. Fortunately they never got any further than the homes of the five families mentioned, and their small size and the dispatch with which they were cleared put the whole thing down as petty froggery, which didn't even draw full-throated complaint.

To drink deep at Bahrein on the Persian Gulf doesn't mean to imbibe large quantities of the public water supply, which must be distilled from sea water, but to dive down to the bottom of the gulf to sip from the springs which flow there. Or if you insist on drinking from a glass, you can purchase a supply from one of the divers who plunge to the bottom with collapsed goatskins to collect the water water.* With all the oil riches of the area, one would think that some better means than goatskins could be devised for making the spring supplies available for surface consumption. But in Persia, of course, they're rugged!

Ila is what they'll be calling the capital of the Philippines any day now if the 30 Manila detectives assigned to catching a particularly audacious and muscular thief now operating in the city's streets aren't soon successful. How the "Man" may drop out of the picture ought to be pretty obvious from the fact that the thief had, at last reports, already pilfered sixteen manhole covers and was increasing his rate of take rapidly. Or maybe just plain "Il."

Hammond Iron Works of Warren, Pa., is planning a merger with Henry Sears & Co. of New York which, if completed, will result in the formation of a new company to carry on and expand the present Hammond business.

*With "underground water" known as "ground water," "underwater water" must, of course, be known as "water water." It is this type of water about which the Ancient Mariner ranted so, probably because he could find no goatskin.

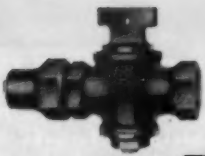
(Continued on page 40 P&R)

For a Trouble-Free Installation . . .

use HAYS®

MODEL B TAPPING MACHINE

CORPORATION STOP



ROUNDWAY CURB STOP

These three outstanding HAYS products team up to give you more service connections per day, week, and month.

The HAYS Model B Tapping Machine, now made of aluminum alloy, is one-third lighter, easier to handle, easier to operate . . . really designed for "the man in the ditch."

Check the HAYS catalog for the complete line of Corporation and Curb Stops conforming to all A.W.W.A. Standards. Write us for a copy or see your HAYS distributor.

Water Departments all over the country have been using HAYS Water Service Products for over 80 years.

HAYS®
WATER WORKS PRODUCTS
HAYS MANUFACTURING CO.
ERIE, PA.

(Continued from page 38 P&R)

Harry E. Lundquist, Neptune Meter Co. representative in Minnesota and the Dakotas since 1928, has retired and will be succeeded by his son Howard and by Robert J. Wigley. Wigley will cover North and South Dakota; Howard Lundquist will cover Minnesota.

Ralph W. Coho Jr. has been named president and Robert P. Nick general manager of Pleuger Submersible Pumps, Inc., of Lancaster, Pa., and Los Angeles. Chairman of the board is Friedrich W. Pleuger of Germany.

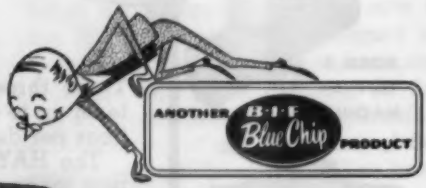
Continental Pipe Mfg. Co., makers of wood stave pipe and tanks, has moved from 3901 Woolworth Bldg., New York 7, N.Y., to 1336 Wellington Gate, West Englewood, N.J.

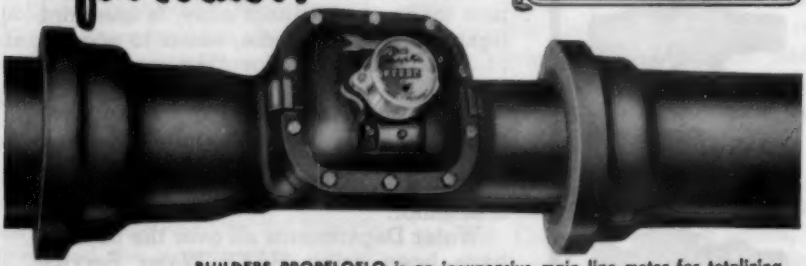
R. P. Farrell, director of the Div. of San. Eng., State Dept. of Public Health, Nashville, Tenn., drowned on January 8 as the result of an accident while fishing. He had been with the Department since 1933 and had receized his Section's Fuller Award in 1942 for his work in water utility rating and operator certification. In addition, he served as Kentucky-Tennessee Section secretary from 1943 to 1952 and director in 1943 and 1944.

Electro Rust-Proofing Corp. has opened a new division office at 3 Rhodes Center, N.W., Atlanta, Ga., under the supervision of R. B. Mills, division manager, and J. A. Lehmann, division engineer. The new office will serve an eight-state area in the Southeast.

(Continued on page 42 P&R)

What a Meter for Water!





BUILDERS PROPELOFLO is an inexpensive main line meter for totalizing water consumption. Gives dependable, trouble-free service on the job. Meters accurately over wide range — six-digit totalizer shows water use directly in gallons, cubic feet, etc. For complete information on this easy-to-install meter, write to Builders-Providence, Inc., 365 Harris Ave., Providence 1, Rhode Island.

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SPECIAL MUDS MINED AND PROCESSED FOR WATER WELL DRILLING!

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- **SPINK-Gel**—high-yielding, finest quality Wyoming bentonite. Low water loss! Exceptional lubricating qualities!
- **SPINK-O**—medium weight mud. Combines outstanding qualities of Gleason and Spink-Gel.

Distributorships now open in several choice territories! WRITE, WIRE or CALL Rich Carothers. Telephone 1593, Paris, Tenn.

H. C. SPINKS CLAY COMPANY, INC.
Mines and General Offices
Paris, Tennessee

Spinks

(*Continued from page 40 P&R*)

Selfweld, an inexpensive 100-amp welding machine developed by Lincoln Electric Co. for use by small repair shops and even hobbyists, is said to eliminate the need for skill in controlling the arc. A special welding electrode and holder do the work. The cost of the equipment, complete with accessories, is less than $100.

A water works engineer is needed by the city of Minneapolis, which is asking that applications be made to the Civil Service Commission, 109 City Hall, Minneapolis, Minn. An engineering degree and five years of experience in a utility serving more than 30,000 people are required.

Ludlow Valve Mfg. Co. has purchased the Rensselaer Valve Co. and plans to integrate the operations of the two firms at Ludlow's Troy, N.Y., shops. Increased manufacturing efficiency and economy are expected to result.

You can lead a stork to water, but you can't make him wait—so found a distrait dad-to-be in Hackensack, N.J., last month, when he swung his car into the driveway of the Hackensack Water Co. in the wee hours one morning hunting for the delivery room. Actually, the hospital for which the unmanned Manning had mistaken the water company building was a good two blocks away, and by the time he had returned with a policeman, the stork had already flown the coupe—not, however, until after girling Manning. Despite the subfreezing temperature and the self-help technique, both mama and baby were doing fine, which may or may not have something to do with the environmental sanitation. Next time, anyway, the company promises, it will have its water boiling.

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and you get all of these improved Fire Hydrant features

- AUTOMATIC LUBRICATION
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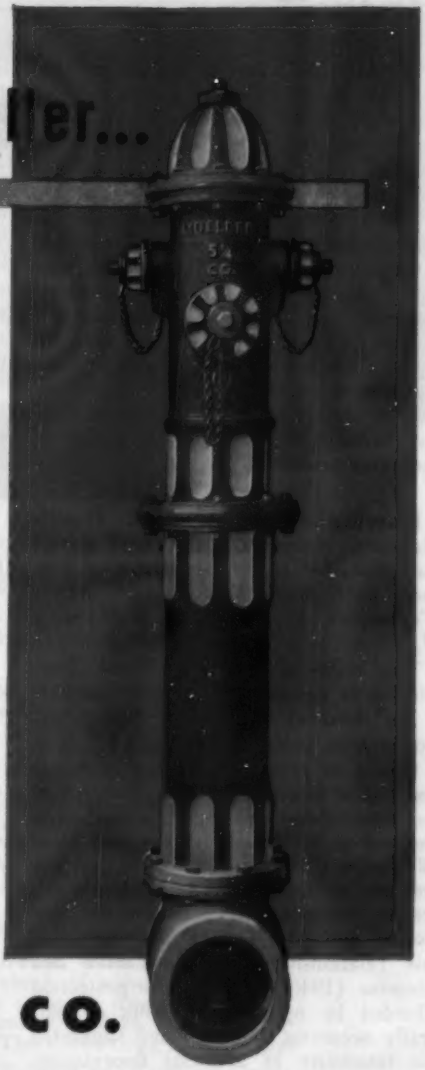
- DESIGNED FOR ABOVE GROUND MAINTENANCE

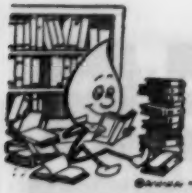


Add Mueller Catalog A-201 to your Fire Hydrant catalog file. Write today.

MUELLER CO.

Dependable Since 1857

CHATTANOOGA, TENNESSEE



The Reading Meter

The Nation Looks at Its Resources. *Report of the Mid-Century Conference on Resources for the Future. Resources for the Future, Inc., 1606 New Hampshire Ave., N.W., Washington 9, D.C. (1954) 418 pp.; paperbound; $5*

One of the eight sections into which the conference was divided was concerned with water resource problems, and this report presents a systematic sampling of opinions taken from the record, as well as the chairman's summary. Among topics discussed by the participants, who represented many organizations and interests (including AWWA), were: supply, pollution, control and administration, and reimbursement.

Fluoridation as a Public Health Measure. *James H. Shaw, ed. American Assn. for the Advancement of Science, 1515 Massachusetts Ave., N.W., Washington 5, D.C. (1954) 232 pp.; $4.50*

This book—a "must" for those interested in or concerned with fluoridation—is the third of a series of fluoridation monographs published by AAAS. It is a tribute to research workers in dental and public health that three surveys in less than fifteen years could reflect such tremendous strides. *Fluorine and Dental Health* (1941) surveyed the evidence that mottled enamel is attributable to excessive fluorides, and considered the control of and possible benefit inherent in this relationship. *Dental Caries and Fluorine* (1946) reviewed the protection afforded by optimum amounts of naturally occurrng fluorides, and suggested the feasibility of artificial fluoridation. And the present volume, based largely upon AAAS conferences as long ago as 1951 and 1952, considers water supply fluoridation as a widely used and generally accepted public health procedure.

In addition to papers on engineering and laboratory aspects of water fluoridation, contributed by such persons as O. J. Muegge and M. Starr Nichols, there are summaries of the various effects of fluorides on health, including several long-term studies. An examination of alternative vehicles for fluoride supplementation concludes, as might be expected, that "water is the most reliable vehicle" and that it is also the only vehicle of which the benefits and potential hazards are fully understood.

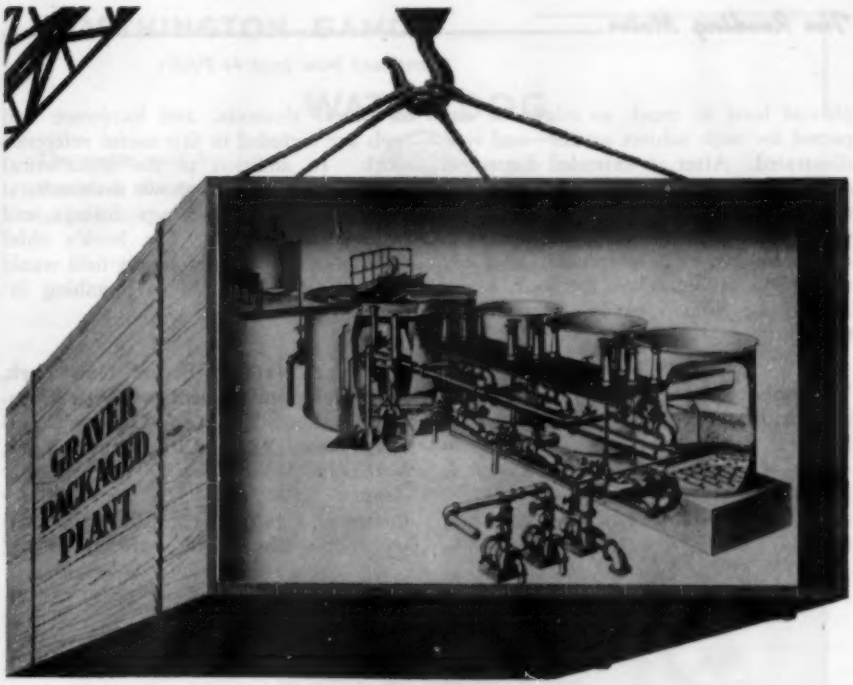
Modern Pumps: *A comprehensive survey of modern pumping equipment and practice. E. Molloy, ed. George Newnes Ltd., Tower House, Southampton St., Strand, London W.C. 2, England (1953) 240 pp.; 21s (about $3 US)*

Centrifugal, reciprocating, and rotary pumps are described and their characteristics examined in this little study. A section of the book deals with their proper installation and maintenance, and separate chapters are devoted to pumps for boiler feed, wells, and special applications (such as irrigation). The "trouble-shooting" section is particularly interesting.

A Treatise on Applied Hydraulics. *Herbert Addison. John Wiley & Sons, Inc., 440—4th Ave., New York 16, N.Y. (4th ed., 1954) 724 pp.; $9.50*

The author of this standard reference work has renewed its usefulness by adding to and revising the Third Edition of ten years ago. The text is clear and sim-

(*Continued on page 46 P&R*)



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The Reading Meter

(Continued from page 44 P&R)

ple—at least as much as might be expected for such subject matter—and well illustrated. After an extended discussion of the fundamental principles, the author discusses their application to flow in pipes, pumping, turbines, and hydraulic measurements. The placement of a key to symbols at the back of the book, where it may be located easily, is a helpful touch.

Handbook of Building Terms and Definitions. *Herbert R. Waugh & Nelson L. Burbank. Simmons-Boardman Pub. Corp., 30 Church St., New York 7, N.Y. (1954) 421 pp.; $5*

Definitions and a generous sprinkling of illustrations of building materials, structural elements, and hardware and tools are included in this useful reference work. In addition to the alphabetical listings, an appendix shows architectural and plumbing symbols, pipe fittings, and geometrical figures. The book's chief usefulness in the water supply field would seem to be as an aid to plumbing inspectors.

Ground Water in Bronx, New York, and Richmond Counties With Summary Data on Kings and Queens Counties, New York City, New York. *Nathaniel M. Perlmutter & Theodore Arnow. Bul. GW-32, State Water Power & Control Com., Dept. of Conservation, Albany, N.Y. (1953) 86 pp.,*

(Continued on page 48 P&R)

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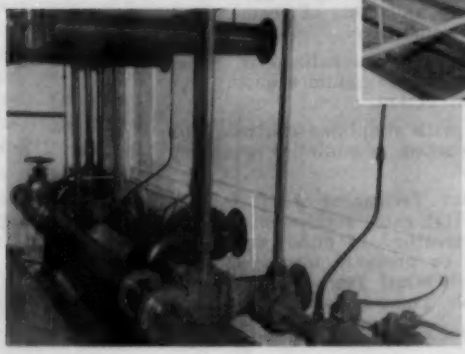

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(Continued from page 46 P&R)

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About 13 per cent of the 1.2 bgd average consumption in New York City's five counties was supplied by ground water during 1949, a shortage year. The data on ground water characteristics and utilization was prepared by the US Geological Survey in cooperation with the state agency.

The Ground-Water Resources of Washington County, New York. *R. V. Cushman. Bul. GW-33, Water Power & Control Commission, State Dept. of Conservation, Albany (1953) 65 pp., maps; paperbound; free from US Geological Survey, Box 590, Albany 1, N.Y.*

This report on a portion of east-central New York state, bordering on Vermont, was prepared by the USGS in cooperation with the state agency. The entire county uses an estimated 4 mgd of ground water, about half of it for public water supply.

Red Lead Paints for Galvanized Steel, Rusted, Weathered, or Treated New. *Red Lead Technical Letter No. 9, Lead Industries Assn., 420 Lexington Ave., New York 17, N.Y. (1954) 5 pp.; paperbound; free*

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(Continued on page 50 P&R)

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The Reading Meter

(Continued from page 48 P&R)

For Junior Engineers

From the utility manager's point of view, a children's book on water supply is a passkey to the sympathy and understanding not only of the child but of those who read it with or to him. These who can recommend educational reading matter for children therefore reach both the father and the child—who is, of course, "father to the man." More and more publishers of juveniles are "doing" water supply in one way or another, and to the books listed below should be added those mentioned in this department in November 1953 (pp. *70-72 P&R*) and, of course, AWWA's own *The Story of Water Supply* (April 1954 JOURNAL, p. *48 P&R*).

The First Book of Water. *Jo & Ernest Norling. Franklin Watts, Inc., 699 Madison Ave., New York 21, N.Y. (1952) 45 pp.; $1.75*

This little science primer, intended primarily for the third- to fifth-grade levels, treats the properties, behavior, and uses of water in a way that will make sense to some younger and many older youngsters. Simple yet detailed illustrations reveal even the mysteries of pumps, turbines, and steam engines. The section on public water supply is sketchy and adds little to the book, but the authors' aim was to present only a general survey of a vast subject, and in this they do succeed.

Water, Water Everywhere! *Mary R. Walsh. Abingdon-Cokesbury Press, 150—5th Ave., New York 11, N.Y. (1953) 48 pp.; $2*

Very different from the tot's picture book of the same name which was mentioned in these pages over a year ago (November 1953 JOURNAL, p. *70 P&R*), this junior monograph is designed for the fourth to eighth grades. The hydrologic cycle, rainfall, the place of streams, lakes, and rivers in human life, commerce, and geography—these and many other topics are discussed and related. The text is straight exposition, lightened only by the descriptive illustrations. Considerable attention is given to oceans, marine life, and navigation.

Make Way for Water. *Eleanor Clymer. An Everyday Adventure Story. Julian Messner, Inc., 8 W. 40th St., New York 18, N.Y. (1953) 63 pp.; $1.60*

A farm boy whose home is on the site proposed for a new reservoir lends dramatic appeal to this story of the growing pains of a metropolis—in this instance, New York. In the course of his adventures, he learns how water is brought from the watershed to the city, sees a little of the purification process, learns the importance of locating and repairing leaks, and most of all becomes reconciled to the mutual dependence of city and country which is moving him off his farm. Skillfully and sensitively done, the information does not get in the way of the story—it *is* the story. For ages 8 and over.

Water for People. *Sarah R. Riedman. Abelard-Schuman, Inc., 404—4th Ave., New York 16, N.Y. (1952) 151 pp.; $2.50*

This excellent little source book for junior high school researchers considers water in its historical role and relationship to life on the planet, and follows through on the same theme today, with a discussion of irrigation, city water supplies, wells, and shortages. In between are outlines of demonstration projects, discussions of the way in which water does or is made to do work, and an explanation of weather and the hydrologic cycle.

(Continued on page 78 P&R)

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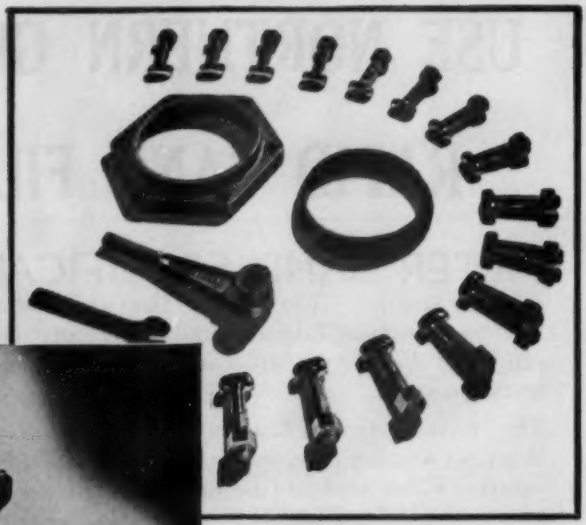

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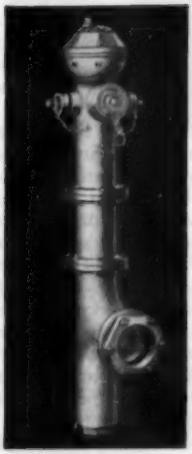

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

FOREIGN WATER SUPPLIES —GENERAL

Chlorination of City's Water Supply [Australia]. H. J. N. Hodgson. Commonwealth Engr. (Australia), **41**:313 ('54). Water supply for south Australian city of Adelaide is obtained from inhabited catchment areas and stored in 3 large reservoirs until needed. In addition to sanitary protection afforded by storage, areas are continuously patrolled to reduce pollution. Also, waste treatment standards for industries located within catchment areas have been established and enforced. During '52–'53 fiscal year, 66% of 990 water samples examined attained, or approached, MPN of 0/100 ml for *Esch. coli* Type 1. Automatic gas chlorination equipment has been installed at 2 reservoirs, and chlorine-ammonia equipment at third. Usual ammonia-chlorine ratio has been 1:8. During first year of operation, all examined water samples met "best drinking water standards." Experience indicates that equipment will be used during wet winter months (May–Sep.) and at other periods following rainfall and reservoir intake.—*PHEA*

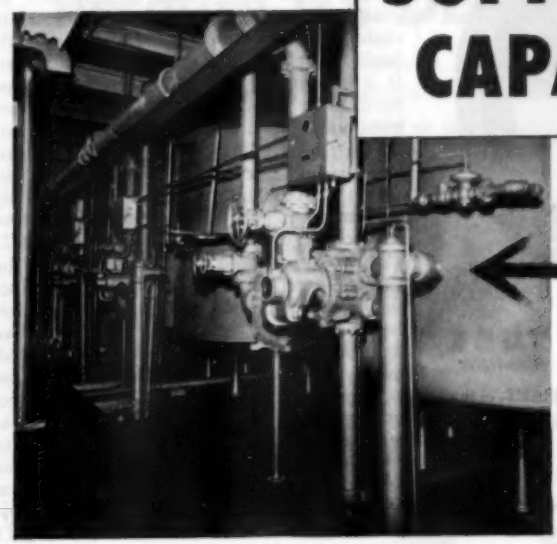
Augmentation of Water Treatment Works. W. L. Hurd. Commonwealth Engr. (Australia), **46**:231 ('54). Report on construction of new coagulation and sedimentation basin, designed to double present capacity of Southern Riverina County (New South Wales) water supply system.—*PHEA*

Review of German Water Works Associations and Their Official Publication. Single, separate German water works association does not exist. More than 80 years ago German Gas Association expanded its activities to include water supply, and, ever since, both branches have worked harmoniously together in the Deutsche Verein von Gas- und Wasserfachmannern (German Assn. of Gas and Water Experts). Recently it joined with three other associations of similar nature to form common organization. 4 member associations maintain their identity, but *Das Gas- und Wasserfach*, almost century-old journal of German Assn. of Gas and Water Experts, became official publication of new organization. Outstanding feature of publication is its evidence of trend toward close cooperation with western democracies. This is natural; even if membership includes East German gas and water works men, their contribution to activities of association can be only nominal. This is confirmed by articles in journal, which mention only names from West Germany. This part of Germany was always closer to western Europe and the other continents than East Germany was. It is in line with this general attitude that western countries outside Germany were invited to association's annual convention. Honorary president of International Gas Union from Brussels addressed convention in French, and president of Swiss Gas and Water Assn. and vice-president of High Authority in Luxemburg (supranational coal and steel organization) in Germany. Some foreign associations sent telegrams. This trend of cooperation with foreign countries has continued. Few months after convention, association asked its members to transmit all incoming foreign literature on gas and water supply to central office, where it would be collected and made available to all members. Furthermore, foreign publications play prominent part in current discussions of books and articles. On other hand, association tries to facilitate study of its own journal by interested parties abroad, giving English and French translations of article titles in table of contents. Issues of journal deal alternately with gas and water, and respective issues are marked on cover accordingly. Brief survey of number of articles may indicate that some are,

(Continued on page 62)

How the Town of Normal, Illinois

TRIPLED SOFTENING CAPACITY



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Recently town officials called in Consulting Engineers, Farnsworth and Conley, of Bloomington, Illinois, who recommended replacing zeolite with modern, high-capacity Permutit Q.

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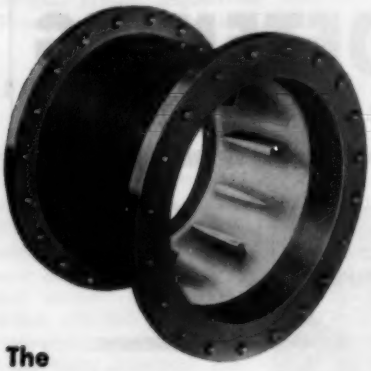

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(*Continued from page 60*)

indeed, worth detailed study. **Stream Protection in Germany.** K. IMHOFF. **95**:33 ('54). Illustrated article, by founder of German sewage treatment technique, stresses paramount importance of industrial-waste effluents, describes different methods of treating industrial and municipal sewage, complains about neglect of necessary steps in dealing with this problem during last 20 years, and recommends immediate efforts to chatch up. 20-year period referred to would begin with 1933, year Nazis came to power. It is known that Imhoff never was on good terms with them, and, though they are not mentioned, limitation of his criticism to that period may imply criticism of defunct Nazi government. Article is on high level consistent with Imhoff's international reputation. **Alteration of Water Utilization Practices in Iron Works.** H. POEHLMANN. **95**:37 ('54). Reports on studies undertaken by German steel industry which aim at reduction of water consumption. Experiments on large scale have indicated that more than half of present consumption can be saved, mainly by repeated use of water. This reuse is suggested, not only for effluent from steel production, but also for domestic waste water within steel mill area after treatment resulting in satisfactory degree of hygienic security. Estimate of so-called consumption after adjustment of steel mills to experimental practice is only 5 cu m (1,320 gal) per long ton (2,240 lb). This indicates that improvement refers only to savings in water lost by evaporation and leakage, as actual use of water for production of 1 ton of steel is many times higher than 1,320 gal. **Control of Stray Currents in Berlin's Gas Pipelines.** M. DEWITZ. **94**:689 ('53). Reports on survey of stray currents in Berlin gas lines. It is obvious that corrosion brought about by such currents also affects water works. Unnecessary industrial water consumption, discussed in preceding article, and leakage both tax available water resources and should be avoided, if possible. Survey of the Berlin gas lines was very thorough. In 10 years of work, from 1929 to outbreak of World War II, all of pipe network was checked, stray currents were measured, and results were listed. Size of job is indicated by length of the pipe network—at that time 7,000 km (4,350 mi). War interrupted almost completed work, and results are now being adjusted to present

(*Continued on page 64*)

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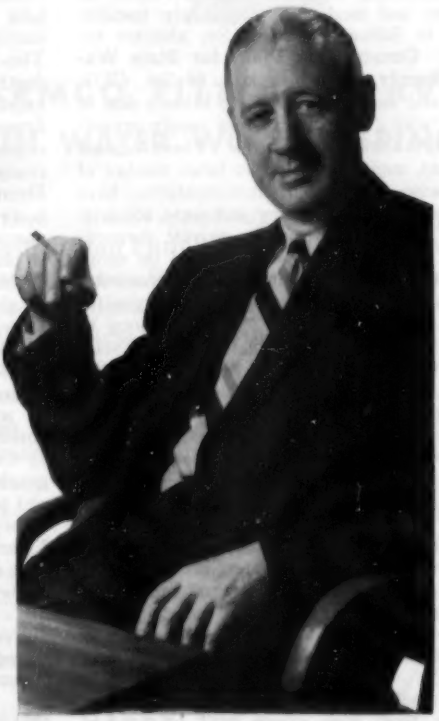

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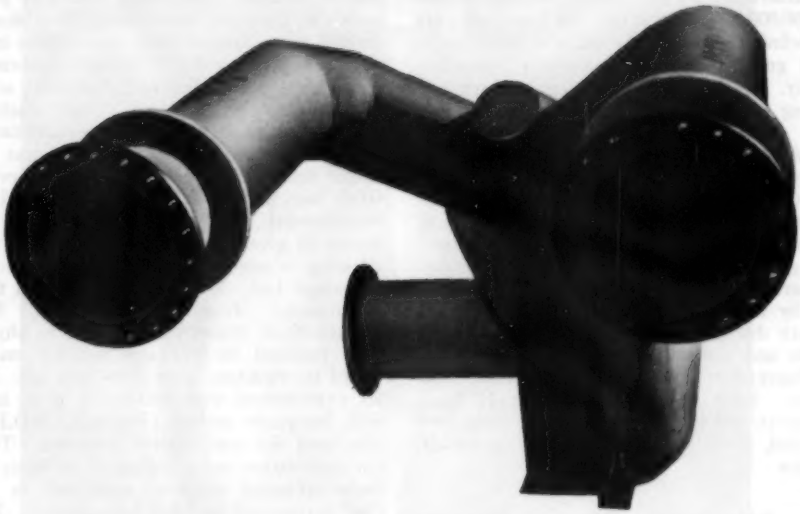
(Continued from page 62)

conditions. **Interrelationship Between Forests and Water.** W. FRIEDRICH. **94**:655 ('53). While the previous two articles concern reduced exploitation of available water resources, Friedrich article deals with maintenance of existing resources. It is pointed out correctly that ground water is endangered, not only by excessive timber cutting, but also by expansion of paved roads, highways, airfields, and other implements of civilization, which replace natural water seepage underground by drainage, carrying water away to remote areas and thus depriving ground water reserves of part of their natural replenishment. Author makes extensive use of foreign literature. Of 31 reference items, total of 13 refer to publications outside Germany, 5 of them American, 3 each Dutch and South African, and 1 each Japanese and Norwegian. Careful attention given to foreign developments is also shown by interesting article, in another issue, on ancient and modern water supply installations in Sahara Desert. [See abstract below.] **Construction Plans for State Water Supply.** E. LANDEL. **94**:594 ('53). This and another article (see below) deal in detail with 2 interurban water supply organizations in southern Germany. These regional systems, supplying water to large number of otherwise independent municipalities, have old tradition in Germany and were administered in various forms: by private corporations, by mixed companies (based on cooperation of private capital and governmental bodies), and by public agencies. Organizations described in these 2 articles belong to last group. One of them, founded by State of Wurttemberg in 1912, supplies water to large part of state, including its capital, Stuttgart. It is not independent authority, but its property is administered separately and managed independently. System always had high reputation for technical efficiency. Article describes 2 phases of expansion: one comprises rehabilitation and enlargement of original ground water supply source; second involves new ground water installation to begin operating in 1956. Annual capacity of old source is about 8.7 bil gal, and daily peak supply is 30 mil gal. New supply source is planned to add 4.75 bil gal to system's annual capacity. Original source was served by 2 main pipelines, 36″ diam., each 62 mi long. Water from new source will be pumped through 32″ pipeline, about 10 mi long, to reservoir on hill, which will be connected with both main pipelines of present supply system. **Planning of Lake Constance Water Supply.** W. EBNER. **94**:583 ('53). Planning new water supply system originating from L. Constance has been undertaken with support of association of cities in Baden-Wurttemberg. "Zweckverband" (cooperative governmental agency) has been founded for construction and administration of system. Members of this agency are municipalities to be supplied with water. Though Lake Constance cannot be compared in size with Great Lakes, it has about same surface area as L. Geneva in Switzerland and L. Biwa in Japan. Volume of water in lake is estimated at 1.7 trillion cubic feet. As Rhine R. flows through lake, it receives summer runoff from Swiss Alps and, therefore, is distinguished by cool temperature and high water level during period of hot weather and peak consumption. Intake will be built on arm of lake for which hilly and sparsely settled surroundings provide natural protection. This arm is about 500′ deep, and intake depth is 200′. All these conditions create excellent source of supply, which is confirmed by fact that, independently of planned regional supply system, 29 water works already use water from L. Constance without filtration or chlorination. Planned system, however, includes filtration. Water will be pumped to reservoirs on hills. Main pipeline is planned with length of about 91 mi and diams. of 56″, 40″, and 36″. Capacity will be about 50 mgd. For more remote future, extension of main supply line to Stuttgart is planned. This connection with water supply system of State of Wurttemberg, discussed in Landel article, will make exchange of water supply between these 2 systems possible, especially in emergency. Article on L. Constance supply system includes demographic and sociological discussion, tables and graphic maps on both subjects, and even reconstructed map of roads, aqueducts, and Limes (kind of Chinese Wall) during period of Roman colonization in Baden-Wurttemberg area. More up-to-date map, showing extent of interurban regional water supply systems in Germany, indicates that such systems cover surprisingly large part of country.—*F. S. Black*

Old and New Systems to Obtain Water in the Sahara Desert. K. RODE. Gas- u.

(Continued on page 66)



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(Continued from page 64)

Wasserfach, 95:42 ('54). Sahara covers 2,300,000–2,700,000 sq mi. Its boundaries are indefinite, as it is only uniform climatically, not geologically, morphologically, or politically. Only about 20% is sand desert, rest being rocky or mountainous. It has no regular streams, as rainfall is concentrated in few hours, occurring once every year to once every 10 yr. These rains cause floods, which help in recharging ground water. Oases exist only where ground water can come to surface prior to evaporating in sand. Dug wells are important source of water. Interesting old method of obtaining water is by trenching from ground water underneath dry river beds or by tunneling under hills and conducting supply in trenches to villages; this method produces up to 12,000 gpm. Since end of World War II many artesian wells, up to 4,000′ deep, have been drilled, with yields up to 3,800 gpm.—*M. Suter*

The River Adhaim Flood of December 1952 and Its Effect on Baghdad [Iraq] Water Works. F. S. Hardy & G. Smethurst. J. Inst. Wtr. Engrs. (Br.), 8:145 ('54). Following period of unusually heavy rainfall in Adhaim R. watershed, river rose from flow of 11.9 to 59,400 mgd within 6 days. River at its flood peak is estimated to have carried with it silt on order of 70,000 ppm. Adhaim R. flows into Tigris R., from which Baghhad takes its drinking water. Sample of raw water from Tigris R. was found to contain 42,700 ppm dry silt, and it is believed that silt content went as high as 50,000 ppm at flood peak. It is believed that no other water works has had to deal with water as heavily silt laden as that reaching Baghdad on Dec. 28, '52.—*PHEA*

SOFTENING

Peat From the Huleh Region in Israel as Ion-Exchange Material for Water Softening. I. Gdalia. Bul. Research Council Israel, 3:3:250 ('53). In view of fact that water throughout Israel is hard (130–300 ppm $CaCO_3$) and cost of imported ion-exchange materials is prohibitive, experiments were started with natural material found in very large quantities in country: peat from Huleh region. Preparation of peat exchanger. Sulfonated peat was prepared in following manner: 1,500 g finely divided peat (approx. 60% combustible material, 28% ash, and 12% humidity) treated with 1,500 ml conc. tech. sulfuric acid. Reaction is exothermic. After reaction cooled down to room temperature, sulfonated peat was washed until wash water was no longer acid, then dried at 110°C and sieved. Grain size fraction 0.5–1.0 mm was used in experimental work. This particle size is known to give satisfactory ion exchange by allowing reasonable rate of flow through exchanger bed. Experiments confirmed this assumption. Practically insoluble, fine grained black product, though not as physically resistant as inorganic zeolites, maintained its structure after prolonged use. In all experiments with sulfonated peat, natural inorganic zeolite (Permutit, B.D.H.) was used for comparative purposes. Two ion exchangers were evaluated on basis of their exchange capacity, expressed in kg $CaCO_3$ removed by 1,000 l of material. 200 ml of each exchange material, varying considerably in weight—sulfonated peat 100 g, and Permutit of same grain size 300 g—were placed in 2 glass tubes having bed depth of 12 cm. Each column was treated few times with 8% NaCl solution and washed with distilled water until wash water was free from excessive chlorides. Jerusalem tap water of 140 ppm $CaCO_3$ hardness was then passed downward by gravity. Samples were taken after every 500 ml for determination of hardness by soap method. Removal of hardness was practically total. This procedure continued without interruption until effluent hardness reached 20 ppm $CaCO_3$, when ability for ion exchanging was taken as exhausted. Water flow was then stopped. On average, this happened after 25 l water passed through peat and after 15 l passed through Permutit exchanger. In terms of exchange capacity, this would mean 17.5 kg $CaCO_3$ hardness removal by 1,000 l sulfonated peat and 10.5 kg $CaCO_3$ hardness removal by 1,000 l Permutit. Result of hardness removal by sulfonated peat compares very favorably with exchange capacity of natural inorganic zeolites, which is generally accepted to be in region of 7 kg $CaCO_3$ per 1,000 l, whereas synthetic inorganic zeolites may have much higher exchange capacity (about 20 kg $CaCO_3$ per 1,000 l). After exhaustion, exchangers were

(Continued on page 68)

BIG valve...little space

The disc in this 84-in. low pressure Butterfly Valve must withstand 138,000 lbs. of force when closed against a 25 P.S.I. line pressure . . . yet the face to face dimension is only 18 in. and the entire valve weighs just 12,000 lbs. Even under this severe loading Pratt design keeps the bearing pressure well below 2500 P.S.I.

Pratt Rubber Seat Butterfly Valves are manufactured in sizes from 10 in. to 168 in. in diameter, in pressure ratings up to 125 P.S.I. Their low initial cost, easy installation and proven low maintenance make them the logical solution to valving problems, both for new projects and as replacements.

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HENRY PRATT

RUBBER SEAT Butterfly Valves

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(*Continued from page 66*)

regenerated in usual way by 8% NaCl solution and washed, and were ready for next softening cycle. Cycle was repeated 8 times with no change in working capacity and no loss in material. Therefore, it is probable that peat from Huleh region, properly sulfonated, can be used as permanent ion exchanger like Permutit and sulfonated coal. Water flow rate per hour was compared for sulfonated peat and Permutit, using—under the same water pressure—80-cm bed depth for both exchangers under same water pressure. Flow rate was same in both units. Ion-exchange capacity of sulfonated peat is 5 times that of Permutit. In practical application, therefore, sulfonated peat will need less frequent regeneration, and consequently less salt and wash water, than Permutit. Costs of treatment may be further reduced by using sea water for regeneration in places situated near sea.—*Ed.*

Is Water Softening Worth While? A. E. BERRY. Munic. Util. (Can.), **91**:10:27 ('53); Eng. Contract Rec. (Can.), **67**:1:124 ('54). Canadian municipal water works systems number more than 1,500, and over 75% obtain supply from surface sources. Of pop. served, 64% use water with hardness not exceeding 120 ppm, and only 10% are supplied with water of hardness greater than 180 ppm. Consequently, softening not widely practiced. Point at which softening considered desirable varies with locality—i.e., depends upon degree of hardness to which consumer accustomed. Much used dividing line of 100 ppm not unreasonable, but, as municipal project, softening likely to be favored only when hardness 300 ppm or more, general practice being to reduce this to 80–90 ppm. No reason to believe hardness detrimental to health. Advantages of softening well known. Many surveys have indicated softening worth while from standpoint of soap saving alone. Reevaluation may be necessary, however, because of increasing use of synthetic detergents. Increasing per capita consumption another factor. Most ests. of comparative costs of municipal and home softening indicate former to be considerably cheaper; in addn., benefits available to all. No doubt that water not of highest quality unless soft.—*R. E. Thompson*

Dealkalization by Chloride–Anion Exchange. ANON. Betz Indicator, **23**:3 (Mar. '54). Dealkalization by chloride–anion exchange is accomplished by passing water through sodium cation-exchange softener, which exchanges calcium and magnesium ions for sodium ions. Water is next passed through second unit which removes anions such as sulfate, nitrate, carbonate, and bicarbonate, and replaces these with chloride. Although not as efficient or economical as acid treatment or hydrogen cation-exchange softening, this procedure has advantage of securing similar alkalinity reduction without necessity of handling acid.—*PHEA*

Expected Life of Anion Exchangers. L. WIRTH, JR. Combustion, **25**:11:49 ('54). Long-term (up to 3.5 yr) data are presented for weakly basic and 2 types of highly basic anion-exchange resins (I) used in com. installations, from which following conclusions are drawn: [1] selection of proper type of I for conditions of water supply being deionized dets. to large extent useful life of I and its operating costs; [2] I life increases considerably with reduction of O content of water; use of vacuum de-aerator is recommended; [3] in addn. to normal degradation rate of highly basic I, org. matter in water supply contributes to capacity shortages and poor water quality; [4] economically useful life of contemporary strong-base resins is about 5–6 yr; [5] careful prepn. of specifications and conservatism in design of deionizers is recommended.—*CA*

Simple Method of Determining the Exchange Capacity of the Cation Exchangers Used in Water Softening. W. NOWAKOWSKI. Prace Placówek Nauk.-Badawczych Ministerstwa Przemysłu Chem., No. 2, p. 39 ('52). Simple lab. method was developed for detg. exchange capacity of cationite (cation exchanger) used in water softening. Two modifications were used: [1] detn. of total exchange value from whole effluent and [2] fractionation of effluent. 2nd modification permitted plotting of ion-exchange graph and detn. of operating exchange value and of exchange efficiency coeff. Ca ions were introduced into cation-exchange column by means of $CaSO_4 \cdot 2H_2O$. Method gave accurate and reproducible results.—*CA*

(*Continued on page 70*)

STEEL PIPE helps cut cost of Philadelphia's long-range program of waterworks improvement

The tracks you see in the photo below are part of the Pennsylvania Railroad's main line. That's one reason why the pipes passing under the tracks are built of strong, *electric welded steel.*

Engineers know from experience that Alco Electric Welded Steel Pipe has the strength and resilience to absorb vibration, impact and overloading that destroy pipe of other types. They know, too, that Electric Welded Steel Pipe offers still other advantages that help cut piping costs. For example: *Efficiency*—smooth, tar-enameled inside surface gives excellent rate of flow. *Economy*—not only is first cost low but sections are long and light, for fast, easy installation. And *durability*—estimated life is 75 to 100 years.

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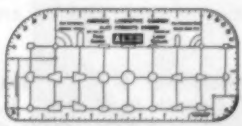

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(Continued from page 68)

CHEMICAL ANALYSIS

Use of Methyl Orange in Determination of Residual Chlorine in Water. P. M. KITVENENKO & V. S. ROZOVSKII. Gigiena i Sanit. (USSR), No. 1, p. 1952 ('54). In usual iodometric determination of Cl in water or that with methyl orange, good agreement was found with actual amounts of Cl added to test solutions. In presence of chloramines, methyl orange method gave results that are consistently below those found iodometrically, but these results checked very well amount of free Cl. Thus methyl orange method is specific for Cl and does not include chloramine values. Methyl orange method has sensitivity of 0.2 mg/l. Procedure: to 100 ml solution add 2 drops 5*N* HCl and titrate with 0.005% methyl orange until weak pink color appears; 1 ml is equivalent to 0.00219 mg Cl.—*CA*

Direct Colorimetric Method for the Determination of Chlorine Dioxide in Water. H. W. HODGDEN & R. S. INGOLS. Anal. Chem., 26:1224 ('54). Reaction between chlorine dioxide and tyrosine was investigated by authors as method for determination of chlorine dioxide in water. Reaction was found to be specific for chlorine dioxide, producing color not affected by hypochlorous acid, chloramines, and manganese. Method is not sensitive for concentrations below 0.2 ppm, which are often encountered in water treatment. At higher concentrations, probable error is 2–3%. Full details concerning characteristics of color complex are given. —*PHEA*

Spectrophotometric Determination of Traces of Copper in Water. L. GHYSSAERT. Bul. Centre Belge Etude et Document. Eaux (Liege), No. 23, p. 56 ('54). Trichloroethanol (I) is used successfully instead of isoamyl alc. required in method of Hoste for detn. of Cu. Dissolve 10 ml H_2O in 90 ml I and then dissolve 2,2'-biquinoline in above mixt. Keep this reagent (II) in dark. To 50 ml of water soln. contg. 1 γ ml of Cu add approx. 0.5 g hydroxylamine-HCl in order to reduce Cu. Then add 10 ml II and stir for 3 min; thus, most of Cu dissolves as complex compd. Decant residue and treat as above; decant and repeat operation until all Cu is dissolved. Absorption curve on spectrophotometer has max. at 550 mμ. Accuracy of detn. is within 0.5%. Regeneration of costly I is also possible.—*CA*

An Operating Method for the Determination of Fluorine in Water and the Fluorine Level in West Germany. G. GAD & E. FURSTENAU. Gesund.-Ing. (Ger.), 75: 352 ('54). Method differs from *Standard Methods* by using as stock solutions 2 stable reagents, one containing zirconoxychloride in hydrochloric–sulfuric acid mixture and other alizarin sulfoacid in water. These are mixed before use to get color reagent. 2 different concentrations of first reagent are used, depending on whether fluorine content is in range of 0.02–0.6 ppm or 0.7–1.7 ppm. Resulting bleaching of color added to water is measured with stable stock solutions containing cobalt chloride and potassium chromate, buffered with primary potassium phosphate. Exact directions are given for all solutions and for procedure of test. Water tested has to be adjusted with normal HCl or NaOH to pH 6–7. Limits of noninterference of various ions are listed. If water exceeds these limits, it has to be pretreated by steam distillation, whereby fluoride ion is changed to hydrofluosilicic acid. This process is fully explained. Method was used in determination of fluorine content of water from 141 towns in West Germany. It was found that only few towns have over 0.2 ppm F, with 0.6 ppm being maximum.—*M. Suter*

Colorimetric Determination of Fluorine in Waters and Soil Extracts. W. M. SHAW. Anal. Chem., 26:1212 ('54). Standard method for determination of fluoride was modified to permit determination in lysimeter leachings, which may be turbid or colored. After testing various decolorizing agents, author proposes use of mixture of carbon and calcium sulfate. In this method, added sulfate does not affect fluoride results because of dilution of samples prior to color development. Other changes in method include: [1] substitution of 0.43 g of zirconium oxychloride in place of 0.3 g of zirconium nitrate to keep zirconium same as in original method; and [2] color development and comparisons are made in 100-ml, Berzelius, tall beakers rather than Nessler tubes. Although standards in steps of 0.2 ppm are recommended, color differences of 0.1 ppm are readily observable.—*PHEA*

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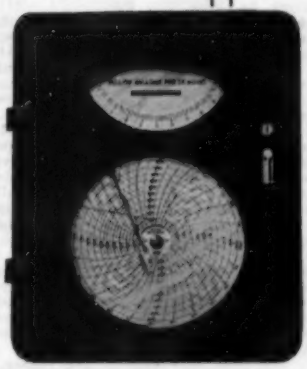

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Ambrey, James W., Sales Repr., American Cyanamid Co., 3505 N. Kimball Ave., Chicago, Ill. (Jan. '55) *P*

Anglin, Charles O.; *see* Mansfield (Ohio) Water Works Dept.

Baker, Charles K., Asst. Chief Engr. & Supt., Water Dept., 4th Floor, City Hall, Kansas City, Mo. (Jan. '55) *MRPD*

Bargh, Samuel J., New England Div. Mgr., American Water Works Service Co., Inc., 311 Washington St., Islington, Mass. (Jan. '55) *M*

Beall Pipe & Tank Corp., Ralph C. Elle, Chief Engr., 12005 N. Burgard St., Portland 3, Ore. (Assoc. M. Jan. '55)

Blanchard, William J., Jr., Chem. Engr., Freeport Sulphur Co., L. C. Route, Box 555, Houma, La. (Jan. '55) *RP*

Blowers, James E., Chief Engr., Up-State Div., New York Fire Insurance Rating Organization, 505 E. Fayette St., Syracuse, N.Y. (Jan. '55) *RPD*

Bond, C. H., Jr., Civ. Engr., Bond Eng. Co., Marion, Ark. (Jan. '55) *RD*

Borame, Raymond L., Asst. Supt., Alameda Div., Water Dept., 425 Mason St., San Francisco 2, Calif. (Jan. '55) *M*

Boriand, William H., Sales Repr., Ellsworth Equipment Co., 2213 N. Meridian, Indianapolis, Ind. (Jan. '55) *RPD*

Brabson, William H., Sr., Cons. Engr., 111 Far Hills Ave., Oakwood, Dayton 9, Ohio (Jan. '55) *MRP*

Brosch, C. W., Supt. of Constr., City Water Board, 106 W. Market St., Box 2449, San Antonio, Tex. (Jan. '55) *M*

Brown, John V., Sales Repr., Miracle Chem. Corp., 1702 Winter St., Fort Wayne, Ind. (Jan. '55) *P*

Burke, Daniel M., Chemist, California Water Service Co., 374 W. Santa Clara St., San Jose, Calif. (Jan. '55) *RP*

Canton, Town of, Douglas P. Walker, Supervisor, Water & Sanitation, Canton, N.C. (Corp. M. Jan. '55) *MPD*

Carrier, Robert R., Div. Engr., Dept. of Health, Parliament Bldg., Quebec City, Que. (Jan. '55)

Clark, M. E.; *see* Frontier Chem. Co.

Coker, Robert M., Plant Mgr., Water Works, City Hall, Jackson, Miss. (Jan. '55) *MP*

Continental-Fremont, Ltd., Cyril Plunkett, Pres., 1620 Sycamore St., Box 333, Fremont, Ohio (Assoc. M. Jan. '55)

Cook, Donald F., Hydr. Engr., Apdo. 102, Barcelona, Venezuela (Jan. '55)

Coursey, W. V., Mgr., Donley County Water Control & Improvement Dist. No. 1, Memphis, Tex. (Jan. '55) *M*

Cummens, William Atkins, Civ. Engr., Oliver Iron Mining Div., Rm. 610 Wolvin Bldg., Duluth 2, Minn. (Jan. '55) *R*

Curtis, George L., Vice-Pres., Eng., United Concrete Pipe Corp., 14041 E. Arrow Hwy., Box 425, Baldwin Park, Calif. (Jan. '55) *D*

Denison, A. L., Water Supt., Carrollton, Tex. (Jan. '55) *MD*

Dukes, Lee S., San. Engr., Water Dept., 600 E. Trade St., Charlotte, N.C. (Jan. '55) *P*

Duncan, A. D., City Secy.-Treas., Carrollton, Tex. (Jan. '55) *MRP*

Elle, Ralph C.; *see* Beall Pipe & Tank Corp.

Everett, Harry W., Pollution Abatement Coordinator, E. I. du Pont de Nemours & Co., Sabine River Works, Orange, Tex. (Jan. '55)

Fahlander, Lennart A., Salesman, James B. Clow & Sons, 1206 W. 3rd Ave., Columbus 12, Ohio (Jan. '55) *D*

Finn, J. Raymond, Constr. Supt., Water Dept., Oak Park, Ill. (Jan. '55) *MD*

Fischer, Kermit, Pres., Fischer & Porter Co., Hatboro, Pa. (Jan. '55) *P*

Frontier Chem. Co., M. E. Clark, Vice-Pres., Marketing, 321 W. Douglas, Wichita 2, Kan. (Assoc. M. Jan. '55)

Gastlin, Frank E.; *see* Royal Pipeline Constr. Co.

Gauvin, Dominique, Chief of Labs., Public Health Dept., City Hall, Quebec City, Que. (Jan. '55)

Ghalib, Mudhafer A., Graduate Student, San. Eng., Univ. of Illinois, 1014 W. Main St., Urbana, Ill. (Jr. M. Jan. '55) *MP*

Gourdeau, Jean Paul, Div. Engr., Dept. of Health, Parliament Bldg., Quebec City, Que. (Jan. '55)

Grapes, Paul W., Supt., Water Dept., Romney, W.Va. (Jan. '55) *P*

Grey, John C., San. Engr., Watson & Hart, 914 Summit Ave., Greensboro, N.C. (Jan. '55) *P*

Gross, Paul A., Gen. Mgr., Chemical Process Co., Box 829, 901 Spring St., Redwood City, Calif. (Jan. '55) *P*

Guillou, John C., Research Asst. Prof., Hydr. Eng. Lab., Univ. of Illinois, Urbana, Ill. (Jan. '55) *MR*

Gunite Assocs., Inc., J. D. White, Pres., 408 N. Midler St., Eastwood Sta., Syracuse 6, N.Y. (Assoc. M. Jan. '55)

Hale, Walton H., Bookkeeper, Water Works & Sewage Office, Box G, Ysleta, Tex. (Jan. '55) *M*

Harrington, G. P., Engr., Johns-Manville Sales Corp., Merchandise Mart, Chicago 54, Ill. (Jan. '55) *MRPD*

Hart, Charles D., Supt., Bessemer Water Service, Bessemer, Ala. (Jan. '55) *M*

Hatch, R. L.; *see* Hunt, Rodney, Machine Co.

Herz, Henry, Consultant, 57 Ardsley Rd., Montclair, N.J. (Jan. '55) *M*

Howell, H. Weston, Salesman, Carlon Products Corp., 4400 Longwood Dr., Charlotte, N.C. (Jan. '55) *PD*

Humphreys, Cyrus H., Water & Sewer Supt., 116 Hickory St., Levelland, Tex. (Jan. '55) *M*

Humphries, Marguerite (Miss), Supt., Water Works, Alexandria, Ind. (Jan. '55)

Hunt, Rodney, Machine Co., R. L. Hatch, Mgr., Water Controlling Apparatus Div., 1 Mill St., Orange, Mass. (Assoc. M. Jan. '55)

Huntamer, Dean H.; *see* Huntamer Water Service

Huntamer Water Service, Inc., Dean H. Huntamer, Vice-Pres., Rt. 9, Box 451, Olympia, Wash. (Corp. M. Jan. '55) *D*

Jagow, Arnold W., Civ. Engr., Public Service Dept., 119 N. Glendale Ave., Glendale 6, Calif. (Jan. '55) *MD*

Johnson, Elwin, Jr. Civ. Engr., Water, Gas & Sewage Treatment Dept., 230 W. Mankato St., Duluth, Minn. (Jan. '55) *M*

Johnston, Charles T., Asst. to the Pres., United Concrete Pipe Corp., Box 425, Baldwin Park, Calif. (Jan. '55) *RD*

Kasting, John, Local Mgr., Hoosier Water Co., Brownstown, Ind. (Jan. '55)

Kastner, Roy W., Civ. Engr., Austin Eng. Co., 115 S. Jefferson St., Peoria, Ill. (Jan. '55) *PD*

Kearns, John E., Power Service Supt., Canadian Arsenals Ltd., St. Paul L'ermite, Que. (Jan. '55)

Keech, Donald K., Geophysicist Asst., Layne-Northern Co., Inc., 2000 Turner St., Lansing, Mich. (Jan. '55) *R*

Krieger, James H., Atty. at Law, Best, Best & Krieger, 8 Evans Bldg., Riverside, Calif. (Jan. '55)

LaForge, John J., Water Service Engr., City Public Service Dept., 164 W. Magnolia Blvd., Burbank, Calif. (Jan. '55) *MRD*

Lawrance, Charles H., Assoc. San. Engr., Bureau of San. Eng., State Dept. of Public Health, Rm. 710, State Bldg., Los Angeles, Calif. (Jan. '55) *P*

Lee, J. Walter, City Secy.-Mgr., Box 787, Marfa, Tex. (Jan. '55) *M*

Leonard, E. N., Supt., Water Works, City Bldg., St. Marys, Ohio (Jan. '55) *MPD*

Levie, Augustus T., Industrial Specialist, Water & Sewerage Industry & Utilities Div., Business & Defense Services Admin., US Dept. of Commerce, Washington, D.C. (Jan. '55) *RD*

(Continued on page 74 P&R)

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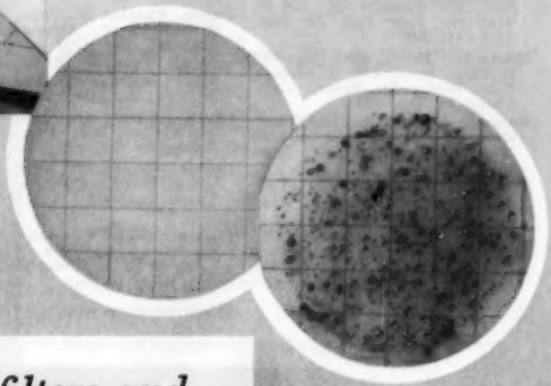

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Lurvey, D. T., Natural Gas Pipeline Co. of America, Box 908, Joliet, Ill. (Jan. '55)

MacKenzie, William Neal, Pres., Naugatuck Water Co., 250 Meadow St., Naugatuck, Conn. (Jan. '55) *M*

Mansfield Water Works Dept., Charles O. Anglin, Supt., Municipal Bldg., Mansfield, Ohio. (Munic. Sv. Sub. Jan. '55)

Marblehead Lime Co., L. B. Robinson, Sales Repr., 300 W. Washington St., Chicago 6, Ill. (Assoc. M. Jan. '55)

Markwood, Ira M., Asst. Service Mgr., The Permutit Co., 330 W. 42nd St., New York 36, N.Y. (Jan. '55) *PD*

Masterflo Meter Co., Ray C. Sparling, Pres., 225 N. Temple City Blvd., El Monte, Calif. (Assoc. M. Jan. '55)

Mattox, James L., Plant Engr., Oldbury Electro-Chemical Co., 1220 N. 12th St., Columbus, Miss. (Jan. '55) *RD*

McGuffin, Sam E., Norwalk Dist. Supt., Southern California Water Co., 11911 S. Vermont Ave., Los Angeles 44, Calif. (Jan. '55) *M*

Moore, Richard R., Supt., Water Dept., Sharpsville, Pa. (Jan. '55) *MP*

Neil, James B., Plant Operator, Salt Lake City Water Dept., Box 908B, Rt. 1, Sandy, Utah (Jan. '55) *MRP*

Nissen, Elmer C., Supt., Water Distr., Water Works, City Hall, Milwaukee, Wis. (Jan. '55) *D*

Ownbey, Charles R., Head, Eng. Div., City Water Board, 106 W. Market St., San Antonio, Tex. (Jan. '55) *M*

Phillips, P. D., Chief Engr., Humble Pipe Line Co., Drawer 2220, Houston 1, Tex. (Jan. '55)

Plunkett, Cyril; *see* Continental-Fremont

Porch, Charles T., Supt., Water & Light Dept., Alexander City, Ala. (Jan. '55) *MPD*

Pownall, Lawrence H., Tech. Supt., American Viscose Corp., Roanoke, Va. (Jan. '55)

Pratt, Charles H., Cons. Engr., 702 Fellows Ave., Syracuse 10, N.Y. (Jan. '55) *PD*

Preble, Stephen E., Cons. Engr., Cherry, Cushing & Preble, 87 W. Tupper St., Buffalo 2, N.Y. (Jan. '55) *RPD*

Puerta, Maria C., Chief, Water Treatment Sec., Tejicos El Condor S.A., Medellin, Colombia (Jan. '55) *RP*

Raw, Robert B., Director, Consumer Service Dept., City Water Board, 106 W. Market St., San Antonio, Tex. (Jan. '55) *M*

Rehm, Gerald F., San. Design Engr., Greeley & Hansen, 220 S. State St., Chicago 4, Ill. (Jan. '55) *MRP*

Rickert, Harold G., Gen. Mgr., East San Bernardino County Water Dist., 1496 Del Rosa Ave., San Bernardino, Calif. (Jan. '55) *MD*

Robinson, L. B.; *see* Marblehead Lime Co.

Robison, George M., Street & Water Supt., Box 351, Ione, Wash. (Jan. '55) *MRPD*

Rodgers, Robert W., Plant Chemist, Brunner, Mond Canada, Ltd., Amherstburg, Ont. (Jan. '55) *P*

Royal Pipeline Constr. Co., Frank E. Gastlin, 11335 Thienes Ave., El Monte, Calif. (Assoc. M. Jan. '55)

Russell, William R., Supt., Water & Sewer Distr., 7512 N. Loop, El Paso, Tex. (Jan. '55)

St. Johns, City of, Everett S. Thompson, City Mgr., St. Johns, Mich. (Munic. Sv. Sub. Jan. '55) *MD*

Sanford, Douglas M., Chief Filter Plant Operator, Water Dept., Rt. 3, Alexander City, Ala. (Jan. '55) *P*

(Continued on page 76 P&R)

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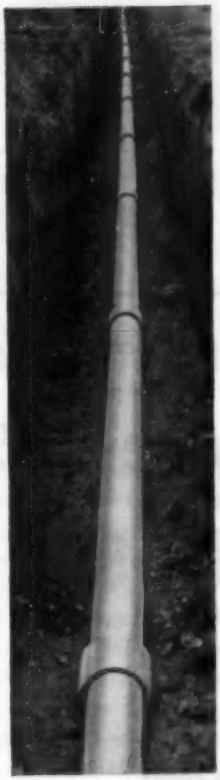

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Scheik, Frederick C., Supt., Public Works, 9 Lapham St., Macedon, N.Y. (Jan. '55) *MD*

Scroggs, Benjamin F., Jr., Mgr.-Operator, Harris County Water Control & Improvement Dist. No. 32, 13349 Vicksburg, Houston 15, Tex. (Jan. '55) *MRPD*

Sheffield, Benjamin, Director of Utilities, Rutledge St., Camden, S.C. (Jan. '55) *M*

Siebrecht, H. R., Director of Distr., City Water Board, 106 W. Market St., San Antonio, Tex. (Jan. '55) *M*

Sisson, Fred U., Chairman, Water Dist. Com., Town of Chenango, Chenango Bridge, N.Y. (Jan. '55) *MRP*

Sparling, Ray C.; *see* Masterflo Meter Co.

Stewart, Robert O., Sales Repr., United Industries Inc., 813 W. 2nd St., Wichita, Kan. (Jan. '55) *P*

Strong, Henry G., Exec. Secy., Refrigeration Industry Safety Advisory Com., 1346 Connecticut Ave., N.W., Washington 6, D.C. (Jan. '55) *RD*

Sullivan, Henry J., Program Exec., Water & Sewerage Industry & Utils. Div., BDSA, Dept. of Commerce, Washington 25, D.C. (Jan. '55) *MR*

Taylor, Lloyd S., Engr., Clyde E. Williams & Assocs., 312 W. Colfax Ave., South Bend 1, Ind. (Jan. '55) *RPD*

Thompson, Everett S.; *see* St. Johns (Mich.)

Thompson, William H., Supt., Water Works, 618 Hampton St., Camden, S.C. (Jan. '55) *MRP*

Todd, David K., Asst. Prof., Div. of Civ. Eng., Univ. of California, Berkeley 4, Calif. (Jan. '55) *RD*

Trammell, Charles R., Sales Mgr., United Industries, Inc., 813 W. 2nd St., Wichita 12, Kan. (Jan. '55) *MRPD*

Trottier, Guy, San. Engr., Ministry of Health, 72½ St. Ursule, Quebec City, Que. (Jan. '55)

Wagner, James E., Water Supt., Box 1002, Gladewater, Tex. (Jan. '55) *MPD*

Walker, Douglas P.; *see* Canton (N.C.)

Wampler, Raymond G., Supt., Water Dept., City Hall, Norman, Okla. (Jan. '55) *MR*

Webb, Arthur J., Safety Coordinator, East Bay Munic. Utility Dist., 512—16th St., Oakland, Calif. (Jan. '55) *MD*

Weimer, J. H., Maint. Supt., City Water Board, 318 Kayton, San Antonio, Tex. (Jan. '55) *M*

Weismann, Victor P., Mgr. of Sales, United Concrete Pipe Corp., Box 425, Baldwin Park, Calif. (Jan. '55) *RD*

Welch, Calvin B., Service Engr., Industrial Chems. Inc., 2215 S. Main St., South Bend, Ind. (Jan. '55) *P*

West, H. B., Supt., Water Dept., Grenada, Miss. (Jan. '55) *M*

White, J. D.; *see* Gunite Assocs.

Wickliffe, A. A., Sales Engr., Evans L. Shuff & Assocs. Inc., 310 Five Ivy Bldg., Atlanta, Ga. (Jan. '55) *MP*

Wiegand, Arthur G., Sales Repr., Miracle Chem. Corp., 1702 Winter St., Fort Wayne, Ind. (Jan. '55) *P*

Williams, James R., Salesman, Wholesale Supply Co., Inc., Jackson, Miss. (Jan. '55) *M*

Wilson, Harry L., Supt., Water System, Mt. Vernon, Ind. (Jan. '55) *MP*

Wolff, Jerome B., Cons. Civ. Engr. & Atty. at Law, 3412 Alto Rd., Baltimore 16, Md. (Jan. '55) *M*

Wright, K. W., Sales Engr., Joseph W. Eshelman & Co., Inc., Box 3605, Charlotte, N.C. (Jan. '55) *RPD*

Young, Richard L., Vice-Pres., Sales, United Concrete Pipe Corp., Box 425, Baldwin Park, Calif. (Jan. '55) *D*

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(*Continued from page 50 P&R*)

The First Book of Conservation. *F. C. Smith. Franklin Watts, Inc., 699 Madison Ave., New York 21, N.Y. (1954) 69 pp.; $1.75*

Ecological balance—"giving and taking," as the author expresses it—holds the center of the stage in this volume, but water supply and watershed care come in for their share of attention. Even the famous watershed management *vs.* big dam controversy over flood control is mentioned. An unfortunate omission is that of the subject of pollution, the control of which is perhaps the most urgent of all conservation measures needed today.

Things Around the House. *Herbert S. Zim. William Morrow & Co., Inc., 425—4th Ave., New York 16, N.Y. (1954) 32 pp.; $1.75*

Large-type text for small readers (seven and up) alternates with more technical, "read-aloud" smaller type for parents or advanced readers. And unless we are mistaken, even parents will enjoy (and be enlightened by) this excellent discussion. Such household utilities as faucets, flush tanks, refrigerators, electric lights, and stoves are discussed, and the illustrations by Raymond Perlman are clear and inviting.

The Wonderful World: *The adventure of the earth we live on. James Fisher. Hanover House, Garden City, N.Y. (1954) 68 pp.; boards; $2.50*

The usual fault of juvenile science books—over-ambition—can be charged against this colorful and handsomely illustrated volume, which, like Sir Francis Bacon, takes all knowledge to be its province. The aspiring water works engineer will be especially interested in those sections which deal with the ways in which wind and water act as agents of geological change, and the importance of rainfall and water to life.

(*Continued on page 80 P&R*)

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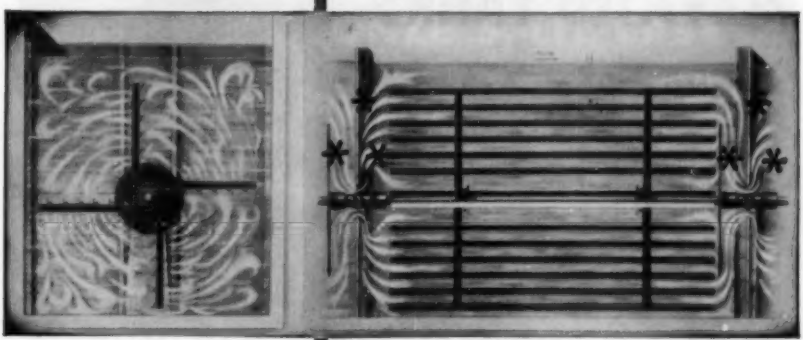

Cross-sectional view from head of tank showing mixing action.

Cross-sectional side view of Floctrol showing flow.

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The Reading Meter

(Continued from page 78 P&R)

Let's Look Under the City. *Herman & Nina Schneider. William R. Scott, Inc., 8 W. 13th St., New York 11, N.Y. (2nd ed., 1954) 71 pp.; $2*

Although its account of water supply sources and treatment methods is somewhat oversimplified and even archaic, this account of urban utility services does somewhat better with the distribution system itself. Considering its target—the 8–11-year bracket, comprising the third to sixth grades—its account of what lies behind the water faucet, light switch, telephone, and other conveniences does seem somewhat dull. As the story element was minimized, the textual content might have been presented in a more exciting way, to attract and hold its public. The subject matter and the basic conception are so good, however, that they might "carry" the execution.

Icebergs and Jungles. *Shirley Carpenter & Marie Neurath. Hanover House, Garden City, N.Y. (1954) 30 pp.; boards; $1*

A little bit of the "why" and much of the "how" of climate should make this book tickle the interest of 10-year-olds. The kind of climate enjoyed—or suffered—throughout the world and its effects upon local culture are explained, together with some brief background on how climate—and particularly rainfall—is what it is. The information tends to be a bit spotty, but the text is reasonably clear and the illustrations good.

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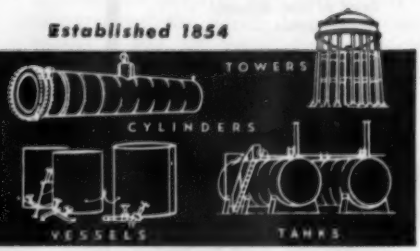

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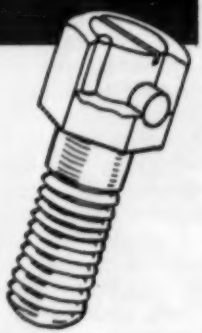

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Section Meetings

West Virginia Section: The West Virginia Section met at the Prichard Hotel in Huntington on Nov. 8–9, 1954. The West Virginia Sewage & Industrial Wastes Assn. held its annual meeting at Huntington on November 9–10, with joint program participation on November 9. The official joint registration for both organizations was 245, including 20 ladies. Official registration for the Section was 212. The meeting was one of the best, with technical sessions very well attended. The program was well balanced and the only criticism heard was insufficient time for discussion because of over-programing.

New section officers elected at the business meeting were: chairman—Henry Gay, Clarksburg; vice-chairman—Charles Whitlock, Madison; trustee—Thurman A. Stout, Clarksburg; and national director —William S. Staub, Charleston.

At the technical session on November 8, Lawson Haynes of Charleston discussed the "Performance of High Rate Clarifier at Charleston." In a paper entitled "Utility Changes Required by Highway Program," Hugh Hetzer of Charleston pleaded for equitable treatment and relief from burdensome relocation costs, and J. N. Wallace of the State Road Commission discussed the laws and regulations which now prevent the commission from assuming these costs.

A symposium on "Water Treatment and Plant Operation Problems," with William Kirchman presiding, included Roy Daniels of Parkersburg, A. G. Timberlake of Hinton, and John Millar of the State Health Dept. Wallace Grant of Charleston discussed plant control tests and Robert D. Norton of Harris Pump and Supply Co. spoke on pump selection. H. K. Gidley of the State Dept. of Health, described the results of a survey of management practices in West Virginia.

The afternoon technical session opened with a showing of the Johns-Manville film "Underground Arteries." A symposium on "Water Supply Problems of the 1953 Drought and Corrective Action" was presented by John B. Douglass of Charleston, Henry Gay of Clarksburg, A. R. Todd of Wheeling, and Bern Wright of the State Dept. of Health. C. C. MacDonald of Charleston presented a discussion of "Water Rates and Inflation." The afternoon session closed with a visit to the Huntington Water Works to observe two 2.5-mgd Aldrich treatment units under construction. John Edwards, plant superintendent, described the units to the group.

The morning technical session on November 9 opened with a showing of the A. P. Smith Co. film, "36-in Valve Insertion Under Pressure." A paper on "Corrosion Control," prepared by C. I. Crockett of Roanoke, was presented by R. S. Bryan Jr. Wendell R. LaDue of Akron spoke on "Water Works Safety." R. J. Faust of AWWA headquarters presented some preliminary information gleaned from employment surveys now being analyzed by the Association.

An open discussion was next held on the subject of district water works meetings. The Section has been sponsoring district meetings for the past two years, but the attendance and local participation have been disappointing.

The Section joined the Sewage and Industrial Wastes Assn. for the afternoon session on November 9. John Lester of

(*Continued on page 84 P&R*)

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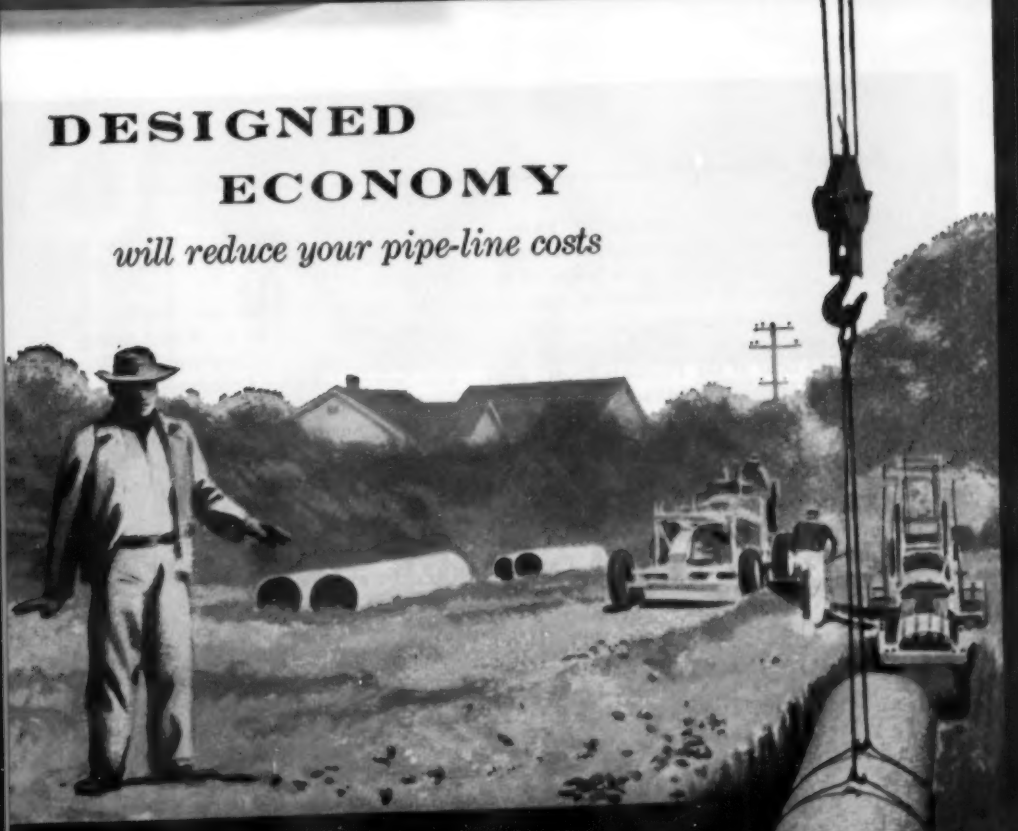

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Section Meetings

(Continued from page 82 P&R)

the State Water Commission gave a Progress Report on pollution abatement. The group attended an open house at the C. I. Thornburg Co. plant to complete the afternoon program.

The concluding event, the annual banquet, was held at the Prichard Hotel with Herman M. Brown of Huntington presiding as toastmaster.

H. K. GIDLEY
Secretary-Treasurer

North Carolina Section: The annual joint meeting of the North Carolina Section, AWWA, and the North Carolina Sewage & Industrial Wastes Assn. was held in Asheville on November 8–10, 1954. The George Vanderbilt Hotel served as convention headquarters. The total registration was 255—well above average for the joint meeting.

With Chairman J. M. Jarrett presiding, a paper entitled "Asheville's Water System" was presented by Thad C. Burnett of the host city.

During the afternoon session Wade G. Brown of Durham presented a very interesting report of work in the use of higher filtration rates. The group then visited Asheville's newly completed water supply reservoir and enjoyed a special barbecue supper and square dance given by the city at the Municipal Auditorium.

The Tuesday morning session featured three excellent papers entitled: "The Use of Water for Irrigation Purposes," by Beverly C. Snow of Raleigh; "Development of Adequate Water and Sewer Rate Structures" by Richard Hazen of New York; and "Operation of Municipal Sewage Treatment Plant at Salisbury" by John N. Leslie Jr.

The honorary luncheon, given in recognition of national officers and other honored guests, was held on Tuesday, and was followed by an address by AWWA President Dale L. Maffitt. The annual business meetings of the two organizations followed. The newly elected AWWA officers are: chairman—Stanford E. Harris; vice-chairman—Robert S. Phillips; secretary-treasurer—Wilbur E. Long Jr.; director—W. M. Franklin.

A Water and Sewage Works Symposium, with George S. Moore acting as moderator, featured discussions of "Water and Sewer Service Connection Charges" by D. J. Gore of Fayetteville; "Demand Charges, Sprinkler Charges, and Hydrant Rentals" by D. M. Williams of Durham; and "Sewer Service Charges Applying to Unusual Commercial and Industrial Wastes" by R. S. Phillips of Charlotte.

The annual banquet and dance held Tuesday evening was presided over by Chairman Jarrett. President Maffitt presented Life Membership certificates to Martin Swartz and George S. Moore. The Fuller Award nomination was accorded to George S. Rawlins of Charlotte, and the M'Kean Maffitt Membership Cup was awarded to Mrs. Ethel Young of Raleigh, for having obtained the most new members for the Section during the year. The principal address was delivered by Walter Smith, Metropolitan Life Insurance Co. representative of Rutherfordton.

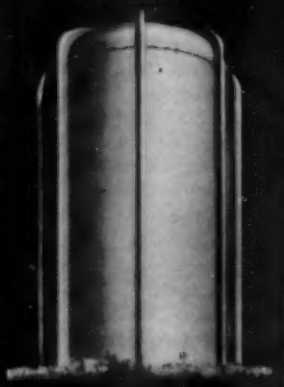
Chairman Harris presided over the Wednesday morning session which featured a discussion period during which everyone was invited to raise questions concerning papers previously presented. This very interesting session was followed by a film entitled "Better Fishing" that presents interesting information about fishing in North Carolina. The entire program was of excellent quality and most people agree that it was highly rewarding.

E. C. HUBBARD
Secretary-Treasurer

Southwest Section: The Southwest Section held its 43rd annual meeting in El Paso, Tex., Oct. 17–20, with Harlan H. Hugg, general manager of the El Paso Public Service Board, serving as host. Registration totalled 680.

The technical program began with a panel discussion on "Public Water Sup-

(Continued on page 86 P&R)



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5 million Gallons

500,000 Gallons

400,000 Gallons

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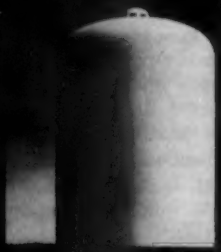

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Section Meetings

(Continued from page 84 P&R)

ply Policies of the State Health Department," by a representative of each of the departments in the Southwest: J. T. Herron (Arkansas), S. J. Phillips (Louisiana), G. F. Mathews (Oklahoma), and V. M. Ehlers (Texas).

Some of the notable speakers during the conclave included William Katz, Ionics, Inc., Cambridge, Mass.; John H. Arnold, assistant chief engineer, National Board of Fire Underwriters, Chicago; John A. Carollo, consulting engineer of Headman, Ferguson, and Carollo, Phoenix, Ariz.; J. A. Frank, vice-president, general manager, National Water Main Cleaning Co., New York; A. C. Perkins, Centriline Corp., New York; and R. S. Rankin, San. Eng. Div., Dorr-Oliver, Inc., Stamford, Conn.

The following new officers were elected: chairman—John E. Williams, water superintendent, San Angelo, Tex.; vice-chairman—John H. O'Neill, director, Div. of Public Health Eng., State Board of Health, New Orleans, La.; and, as trustees: Marion R. Ulmer, Jonesboro, Ark.; John E. Trygg, New Orleans, La.; W. W. Wheeler, Tulsa, Okla.; and Haskell R. Street, El Paso, Tex. Leslie A. Jackson was continued as secretary for a term of one year.

The Fuller Award went to Fred Leon McDonald, chief sanitary engineer, State Board of Health, Little Rock, Ark., for his outstanding contribution as chairman of the Licensing Committee.

The official hosts included Mayors Fred Hervey of El Paso and Pedro Garcia of neighboring Juarez, which furnished a great deal of the entertainment for the visitors.

LESLIE A. JACKSON
Secretary-Treasurer

Florida Section Meeting: The Florida Section held its annual conference Nov. 7–10 at the Sorena Hotel, St. Petersburg, jointly with the Florida Sewage & Industrial Wastes Assn. Total registrations reached 305, including 83 ladies.

The technical sessions opened Monday morning as both groups, in a joint session, heard addresses by the national representatives of both organizations. David B. Lee, president of FSIWA, spoke on "Water Pollution—One Phase of Water Conservation" followed by AWWA Vice-President Frank C. Amsbary Jr., whose paper was on "The Air Conditioning Water Usage Problem." Ross E. Windom, of St. Petersburg, discussed "Financing Water and Sewerage Systems" and Eugene Brown of the Geological Survey addressed the group on "Sources of Water Supply." George E. Owen, assistant attorney general, discussed "Legal Implications of Stream Pollution."

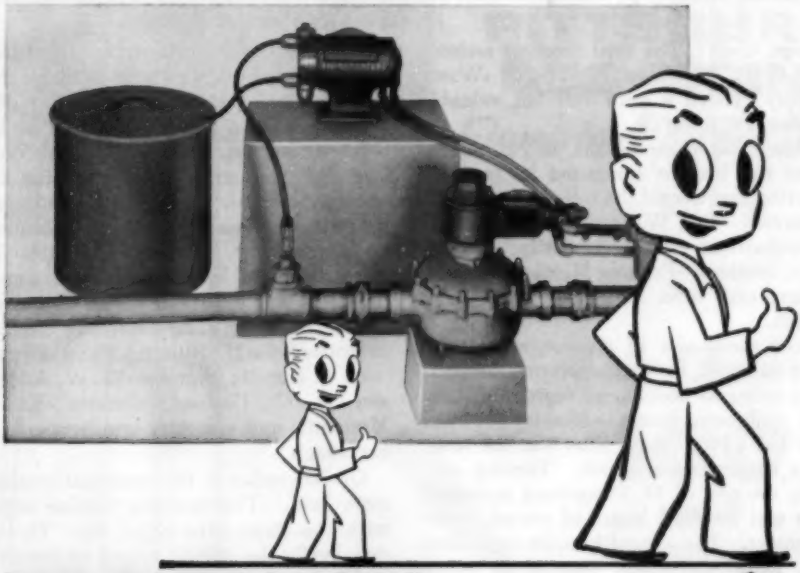
The Monday afternoon sessions were separate, with the Florida Section of AWWA hearing talks on "Remote Control of Water Systems" by E. Wylie Head, "Development of St. Petersburg Water Supply" by Harry Oberly and "Problems of Revamping Old Water Systems" by Paul E. Langdon.

Tuesday found both groups again meeting jointly to hear informative presentations. Frank E. Maloney surveyed the "Laws of Florida Governing Water Use," and Robert M. Angas spoke on "Well Cleaning in Florida." Because of the great interest in the final subject—"The Red Tide of the Florida Gulf Coast"—an address by James B. Lackey of the University of Florida was well attended and very much appreciated.

On Wednesday again the groups met jointly to hear addresses of mutual interest, beginning with T. H. Forrest's address on "The Catalytic Reduction Process" and followed by "Biological Studies in Stream Pollution" by W. M. Beck Jr., and "St. Peterburg's Sanitary Sewerage Problem," presented by W. W. Gillespie.

The afternoon technical session offered only two papers but their quality made up for the shortage in number. A very interesting talk and clever demonstrations highlighted the presentation by Marcus Donaldson on "Electronics—Wide

(Continued on page 88 P&R)



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Section Meetings

(Continued from page 86 P&R)

Range Use." The final meeting address by A. P. Black on "Industrial Water Supply" ended a very full but valuable conference program.

After the close of the technical sessions the Section conducted its business meeting and elected the following officers: chairman—Don W. Jones, North Miami; vice-chairman—John R. Kelly, Gainesville; trustees—Frances Middleton, Clearwater, and John Simmons, West Palm Beach.

The social side of the convention was very full with the manufacturers' association acting as hosts to all registrants during clubroom hours. Monday evening the Tides Hotel Bath Club was the scene of a barbecue and dance. Tuesday evening the city of St. Petersburg presented two and one-half hours of varied entertainment. The annual banquet and dance was held Wednesday evening at which time the awards were made and new officers introduced. Clifford Earls was the winner of the A. P. Black Award; C. F. Wertz received his Life Membership Award from AWWA Vice-President Frank C. Amsbary Jr.; and Chairman Marvin Boyce announced that the Fuller Award nomination went to David B. Lee.

All attending indicated that in their opinions the meeting was an outstanding one and thoroughly enjoyed by all.

HARVEY T. SKAGGS
Secretary-Treasurer

Virginia Section Meeting: The 21st annual meeting of the Virginia Section was held at Richmond on Nov. 3–5, 1954. Registration totaled 230, including 38 ladies, for whom a fashion show and tea was held on Nov. 4.

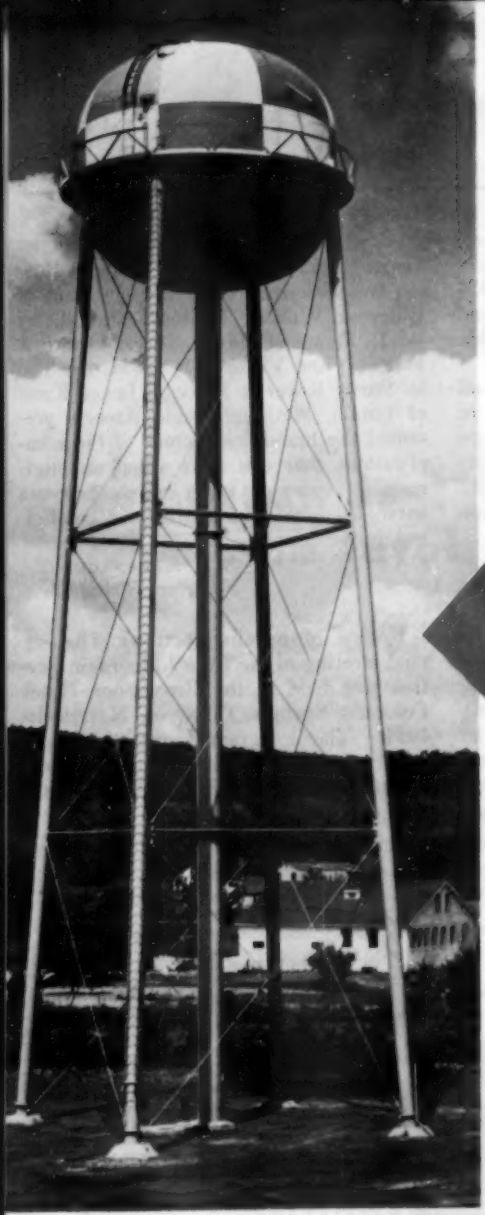
The morning of November 3 was spent in registration; visits to Richmond's water filtration plant, new 5-mil gal prestressed concrete storage tank, and automatic pumping station; and tours through the Liggett & Myers tobacco factory.

In the afternoon, J. H. Wyse, Virginia Coordinator of the Office of Civil Defense, described federal stockpiling of emergency water purification and distribution equipment which is available for disaster use. He also discussed radioactive fallout, a secondary effect of H-bomb detonation. A. E. Griffin of Wallace and Tiernan Inc. spoke on the use of activated silica as a coagulant, and operating experiences with this chemical on a very soft water at Charlottesville were described by C. G. Haney, superintendent of filtration. The following officers for the coming year were elected: chairman—G. H. Ruston; vice-chairman—H. F. Knoell; trustees—W. W. Anders and E. C. Coalson; director—E. C. Meredith; and secretary-treasurer—J. P. Kavanagh.

On November 4, two technical sessions were held. The morning session began with the impressive color film "Operation Ivy"—the official record of the first H-bomb test. T. McM. Niles of Greeley and Hansen then presented a graphic analysis of construction costs in sanitary engineering and projected these to a logical prediction of future costs. A panel led by Richard Messer of the Virginia State Health Dept. discussed various problems of smaller water works. E. C. Coalson of Bristol described a streamlined billing and accounting system. Brent Remsberg of South Boston spoke on the reconstruction of the local distribution system and the highly successful public relations program which eliminated consumer complaints despite the many necessary interruptions of service. R. P. Mowry Jr. of Salem discussed problems with a water supply which exhibits extremely rapid and drastic chemical and physical changes. C. C. Kestner of Harrisonburg described the town's unique underground dam.

In the afternoon, a movie illustrating basic hydraulic laws in an animated fashion was shown. F. C. Amsbary Jr., AWWA vice-president, then conveyed the greetings of the Association. A description of types and applications of vertical pumps was presented by D. L.

(Continued on page 90 P&R)



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Section Meetings

(Continued from page 88 P&R)

Gallagher of the Worthington Corp. D. S. Wallace of the US Geological Survey spoke on the effect of the 1954 drought on Virginia water supplies and presented a cyclical theory for Virginia droughts.

In the evening the annual banquet and dance was held. At the conclusion of the banquet, the following awards were announced: Fuller Award—X. D. Murden; Life Membership Certificates—C. E. Moore and J. D. Capron; Old Dominion Citation—W. B. Harman and D. S. Wallace.

On November 5, the last technical session was held. G. R. Talcott of R. Stuart Royer & Assocs. illustrated the development of an integrated water system in a metropolitan area by describing the design of a system for Henrico County which purchases its water wholesale from Richmond. Details of several new water works in Virginia were given by a panel presided over by G. L. Mattern of Hayes, Seay, Mattern & Mattern. South Boston was described by W. M. Johnson of Wiley & Wilson; Radford Arsenal, by W. L. Myers of Hayes, Seay, Mattern & Mattern; and Victoria, by E. H. Ruell of R. Stuart Royer & Assocs. James Rives of Lublin, McGaughy, and Assocs. presented the humorous picture of the complications that can arise when an engineering report on water supply becomes entangled with local politics and conflicting jurisdictions.

J. P. KAVANAGH
Secretary-Treasurer

Rocky Mountain Section: The annual meeting of the Rocky Mountain Section was held at the Broadmoor Hotel, Colorado Springs, Colo., on Nov. 9–10, 1954. The Program Committee under Chairman Thomas Eaton prepared an excellent program, which together with the

(Continued on page 92 P&R)

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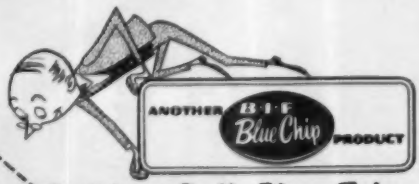

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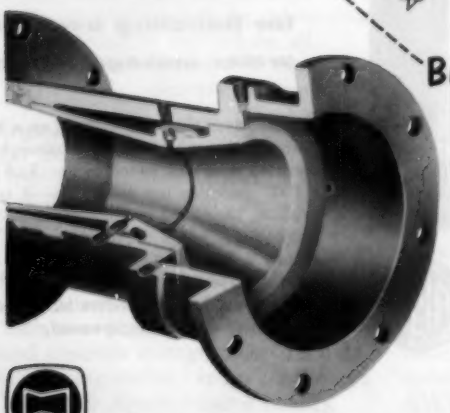

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Section Meetings

(Continued from page 90 P&R)

excellent weather and the picturesque setting, attracted a large attendance, with a total registration of 139. As usual, the water works meeting was preceded by a one-day meeting of the Rocky Mountain Sewage Works Assn.

Tuesday morning, November 9th, was devoted mainly to registration and a business meeting. AWWA Secretary Harry E. Jordan spoke on engineering unity and emphasized the importance of universal metering.

Tuesday afternoon's session was devoted to the following subjects: "Need and Study for Underground Water Control and Legislation," presented by Thad McLaughlin of Denver; the motion picture "Deep Waters," shown by Layne & Bowler, Inc.; "Our Water Supply for the Future" discussed by Allen P. Mitchem, Denver; "Water Distribution Storage," by Donald G. Mees, Denver; and "FHA and VA Requirements for Subdivisions" by T. V. Williams, Denver. During the day, 44 ladies attended a complimentary luncheon at the Garden of the Gods Country Club, located near Manitou, Colo.

On Wednesday morning the following program material was presented: "A Water Conservation Program" panel led by Earl L. Mosley of Denver; and including C. M. Dixon of Boulder; Thomas J. Eaton of Santa Fe, N.M.; Orville Jones of Pueblo, Colo.; Ben Davis of Rawlins, Wyo. "Problems Confronting a New Water Board" was the topic discussed by Sam Joseph, Denver, and Jack Maguire, Derby, Colo. The motion picture, "Health and the Cycle of Water," was shown through the courtesy of the Cast Iron Pipe Research Assn. "Flow Meters and Level Controls" was presented by Robert Hankison and Ed Ambler, both of Denver.

(Continued on page 94 P&R)

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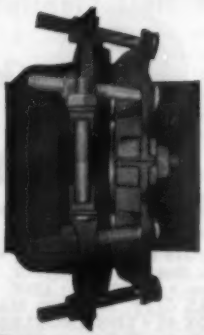

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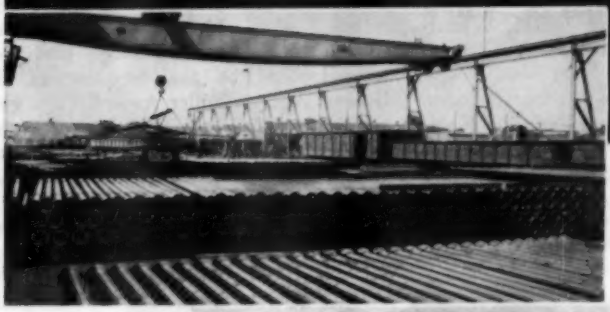

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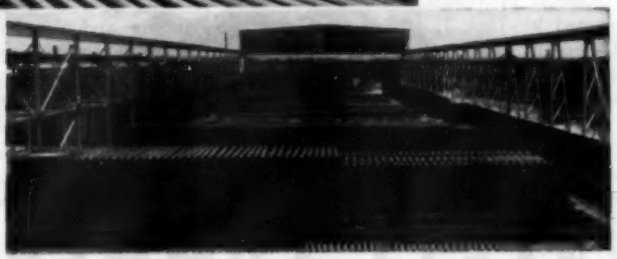

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Section Meetings

(Continued from page 92 P&R)

At the business luncheon Wednesday noon, the following officers were elected: chairman—Thomas J. Eaton, Santa Fe, N.M.; vice-chairman—Orville J. Jones, Pueblo, Colo.; secretary-treasurer—Jack Davis, Denver; trustees—V. A. Vaseen, Denver, and R. Ernest Leffel, Wheatridge, Colo.; and director—George J. Turre, Denver.

The program for Wednesday afternoon consisted of a panel discussion on "Engineering Reports," led by Simon F. Elliot of Pueblo. Others participating were W. F. Turney of Santa Fe, N.M.; V. A. Vaseen of Denver; George Schlitt of Denver; and Henry Barnes of Rocky Ford, Colo. A discussion of "Engineering Aspects of Water Fluoridation" was presented by Jack H. Fooks of Denver, and "Some Things You Should Know About Chlorine and Its Compounds," by Walter D. Smith of Denver. The "Need for Water Plant and Other Utility Fencing" was discussed by William N. Carlile of Denver, and a "Round Table Discussion of Water Operators Problems" was led by J. S. Nichols of Colorado Springs.

Wednesday evening the banquet was held in the dining room of the Broadmoor Hotel with 166 attending. AWWA Secretary Jordan addressed the group, and Chairman Vaseen announced that Ben Davis would be the recipient of the George Warren Fuller Award. The gold lapel pin of AWWA was then presented by the newly elected chairman, Thomas J. Eaton, to the outgoing chairman, V. A. Vaseen.

The technical sessions were well attended. This, together with the brilliant sunshine, outdoor swimming pool, ice skating, horseback riding, dancing, square dancing and the numerous scenic trips, all set in the beauty of the Pikes Peak region, assured a most delightful meeting and a fine experience.

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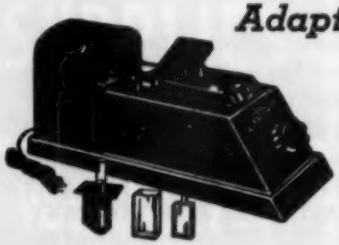

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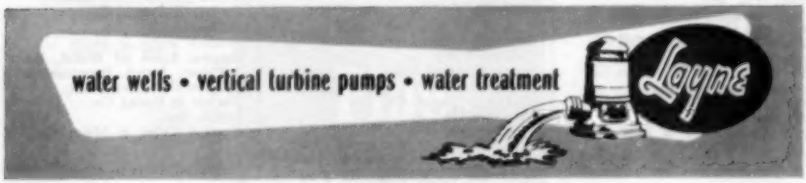

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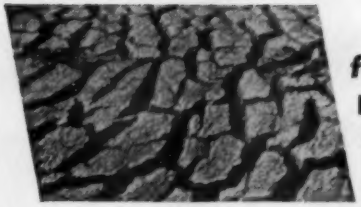

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Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.
Welsbach Corp., Kitson Valve Div.

Taste and Odor Removal:
Cochrane Corp.
Fischer & Porter Co.
General Filter Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Shower Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Shower Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Shower Co.
Foster Eng. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Gulf States Asphalt Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.
Welsbach Corp., Ozone Processes Div.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

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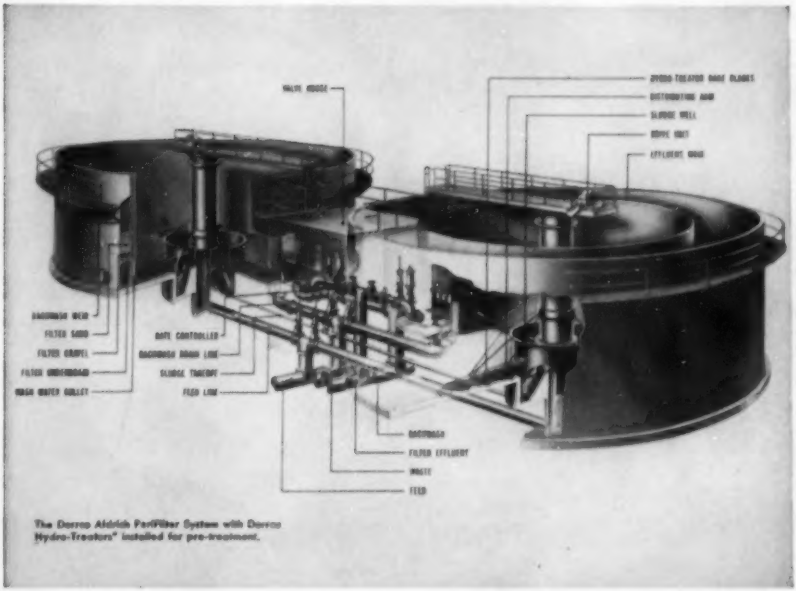

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